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Causal Finality in Bacteria
By Sister Mary Petronella, C.PP.S, Institutum Divi Thomae, Cincinnati, Ohio.

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By James W. Moffett, Chief, Great Lakes Fishery Investigations, Ann Arbor, Michigan.

America's Stake in Patents
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Some Advances in Free Radical Chemistry
By Francis Owen Rice, Department of Chemistry, The Catholic University of America, Washington, D. C.

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Complex Reproductive Processes in Bacteria
By Sister Mary Benita, C.H.M., Department of Biology, Marycrest College, Davenport, Iowa.

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Procedures in Genetics in the High School Laboratory
By Raymond Heckerman, Department of Biology, Duquesne University, Pittsburgh, Pennsylvania.

•

Folic Acid and the Control of Anemia
By Thomas H. Jukes, Lederle Laboratories Division, American Cyanamid Company, New York City.

The Future of Toast

• By **Richard M. Sutton, Ph.D.,** *(California Institute of Technology)*
DEPARTMENT OF PHYSICS, HAVERFORD COLLEGE, HAVERFORD, PENNSYLVANIA

This is a delightful essay to read and to ponder over if you have ever chauffeured an automatic toaster, and especially if you like sober facts flavored with a quiet humor.

Consider carefully the concluding paragraphs. Are we misdirecting our tools of mass production when we make hundreds of gadgets whose functions are better performed by a simple twist of the wrist?

●

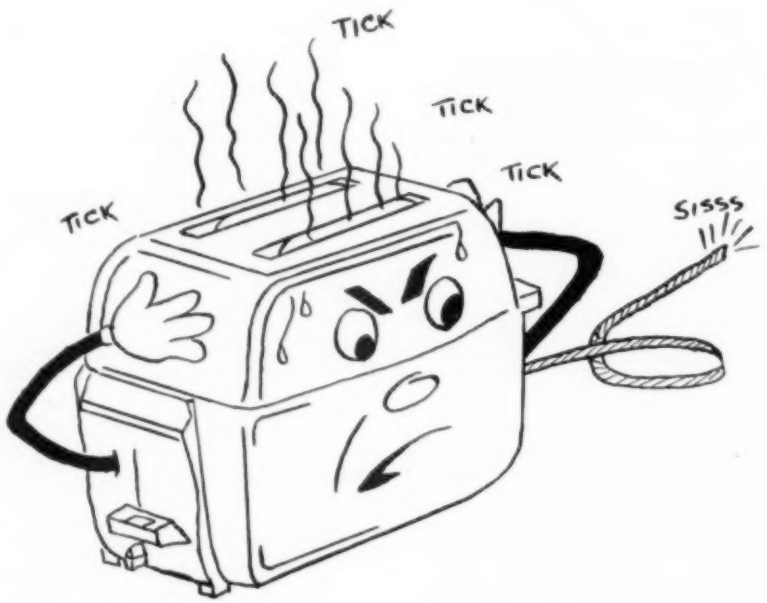
Anyone who has ever changed the brake-bands on an old Model T Ford should know how to rescue toast from an automatic toaster.

For the first twenty-five years of our married life, we made toast by the simple turn of the side panels on a hand-operated electric toaster. Being a wedding present, it was doubtless quite modern in the days when the Model T was still rattling along. Like the Model T, it embodied the mechanical simplicity that has all but vanished from this new age of automatic gadgets. Now the Model T has taken its place with the spinning wheel and the candle mold among the relics of early American culture, and the side-panel toaster has been replaced with the smooth type without running boards.

We needed no book of instructions to run that early model. I do not recall that it ever needed repairing. Of course, we gave it a brushing up now and then to remove the crumbs and we watched its original nickel plate slowly acquire a rich brown patina. It sometimes produced burnt offerings but these were *our* fault. The element of human frailty still prevailed, and although we might accuse one another of criminal negligence in operating it, we wasted no effort in swearing at the manufacturer or at the toaster itself. Personal responsibility was still inescapable, for it embodied the stern doctrine of cause and effect: negligence meant the prompt rising of a pillar of smoke, but attention insured perfect results.

That old toaster was as frank and open as a frying pan. It held no secrets, bore no grudges, did its work without fuss. For more than a quarter of a century it was like a member of the family, until one day we had a visitor. She was a well-meaning but misguided person who looked pityingly upon us and our ancient contraption. Upon her departure, she graciously presented us with a modern streamlined model with an automatic gear shift but no running boards. Somehow she inveigled us to part with the old one under the pretext that she knew someone who needed it. How many times since have we envied the recipient of our Old Faithful!

The outward charm and perfection of this gorgeous new chrome-plated Rolls-Royce of the breakfast table entranced us. Surely, *this* was progress and we had been living for two decades or more in the dark ages of the Twenties while the rest of the world had been marching onward into the Atomic Age and reaching out impatiently for the Twenty-first Century with its promise of bigger and better civilizing gadgets. This proud toaster with front and rear bumpers, fluid drive and automatic windshield wiper clearly showed the results of stupendous engineering skill. It was the lineal descendent of generations of toasters. It had that self-conscious air of superiority which overcomes a young man who discovers how many generations of distinguished forebears it took to produce *him* as the supreme fruit of his family tree. Perhaps this new machine would relieve us of some of the worries we never knew we had. Henceforth, without a doubt, perfect toast would take its place along with death and taxes among the Great Certainties of this world.



Drawings by Thomas Groner, Duquesne University, '52.

With fine precision this sleek monster performed nicely until a few months after the guarantee ran out. Making toast with it is easy: you

simply insert two slices of bread in the slots provided, then shove down on the front bumper until you hit the chassis and relax a bit to allow it to ease back on the shock absorbers. If it fails to push down easily, you put the rest of your weight on the back bumper to hold it to the road. The bread disappears from view and there follows the ominous ticking of a time bomb. In the course of two or three minutes, the bomb goes off, trips a release and up come the two slices. It is foolhardy to call them toast *yet*, for they must first be examined for complexion. Likely as not, they are still anemic. There is nothing to do but shove them down for another go. After the third time down, you rescue them like a drowning man. If resuscitation is needed, you take them to the sink and scrape them just as your grandmother did.

During all this process, the bright and shiny cowling of the toaster has become quite hot. Rescuing toast from the silvery slots is an art in itself, not to be undertaken without care. Fingers won't do; they are too big and besides they may get burnt. A fork is worse, for it is almost certain to shove the slices down to a point from which they are not easily recovered. Two knives, one on either side of a slice, offer an effective pair of tongs; but this isn't in the manual of instructions. Since there is no television set connected with the gadget, one cannot follow the browning process from moment to moment and must wait for the release of the trigger mechanism to inspect the results. It is my firm impression that the mechanism has a smoke-precipitor concealed within it to "eat its own smoke" for the charcoal phase often attains an advanced stage before it is detectable by external symptoms.

We still use an ordinary knife to scrape our toast; but we hope that, now that you can grind your garbage down the sink, someone will invent an automatic scraper with color chart and photoelectric control.

In the last two years, since the guarantee ran out, I have delved into the internal workings of this creation several times. The manufacturers did not intend me to get into it: they sealed up all obvious points of entry just as year by year they put the working parts of an automobile into more and more inaccessible places and make you go to a service station or buy special wrenches to do even the simplest operation. Do you remember the long wrench that came as standard equipment with the Ford car? It fitted every nut on the wagon, and could be used for a tire iron in its spare time. What did I find? The time bomb switch was an ingenious mechanism easily discombobalated but nevertheless sound in principle and almost as simple as an alarm clock. The retriever mechanism was an extensive array of springs and levers with senate and house of representatives and all the necessary checks and balances required by the Constitution. It had obviously been designed by a postgraduate of the Rube Goldberg School. An essentially simple process was thus rendered complex, in the best tradition of the master gadgeteer. Most of those aspects of the device that meet the eye and make it attractive to the housewife are completely non-functional, and the functional parts, such as time control, start-and-stop and retriever are

delicately enough interrelated to make this a gem of modern industrial design.

Behind this toaster, and its many cousins in the gadget family, lies a lot of the misguided effort of our times. With our tools of mass production, we turn out gimmicks, gismos and gadgets by the thousands, some of them scarcely worth the cost of the metal or plastic they employ, some performing functions that are better performed by "a simple twist of the wrist," most of them put up in beautiful cases that are more expensive than the working parts—and that goes for the biggest gadget of all, the haughty mid-century motor car. Into many of our modern devices is being built the priceless ingredient of rapid depreciation and obsolescence. The more moving parts, the faster almost any machine will run into disrepair. Durability is becoming a vice. A schedule of rapid replacement seems needed in anything that is to play a significant part in our planned economy: either it must wear out, or it must be outdated by redesign of the case and cover. Sledgehammer selling methods implemented by press, radio and television, with all of their brazen use of the findings of psychology, add insult to injury by making folks ashamed to continue using old things that still work. Only an economy of war preparation keeps us from promoting a still more rapid turn-over in our forced march toward obsolescence.

There are times when our mechanical world with its burden of chrome-plated shoddy weighs heavily upon me. Then it appears that one can gain relief for a time by making toast on the end of a fork beside an open fire of live coals in the quiet of the woods and discover warmth and smells and tastes long forgotten. One discovers, too, that life is more than gadgets, however ingenious they may be, and that a whole people can too easily be drawn into spending much of the stuff of life on what doesn't really matter, though the deeper needs of their own natures go unsatisfied. ●

New Meanings in Insect Coloration

• By **William Hovanitz, Ph.D.,** *(California Institute of Technology)*
DEPARTMENT OF BIOLOGY, UNIVERSITY OF SAN FRANCISCO, SAN FRANCISCO, CALIFORNIA

Is there ever a direct relationship between the color of an insect and the specific environment with which it is correlated?

Dr. Hovanitz, who has some interesting ideas on the subject, has made some pertinent observations. But, he suggests "there is ample room for much more work before we have the complete answer."

●

The significance of differences in insect coloration has long been a question confronting the insect biologist. Recent transformation of moth populations from light colored forms to dark ones within a period of a few years in industrial regions of Europe could not fail to gain attention and to cause queries as to the biological implication of this change. Experiments aimed at answering the age-old question "Why?" still are not wholly conclusive. Comparable color forms found in populations undisturbed by man show variations in direct correlation with gradients in the climatic environments inhabited by the insects.

One would be tempted to believe that a *direct relation* exists between the *color* of the insect and the specific condition of the environment with which it is correlated.

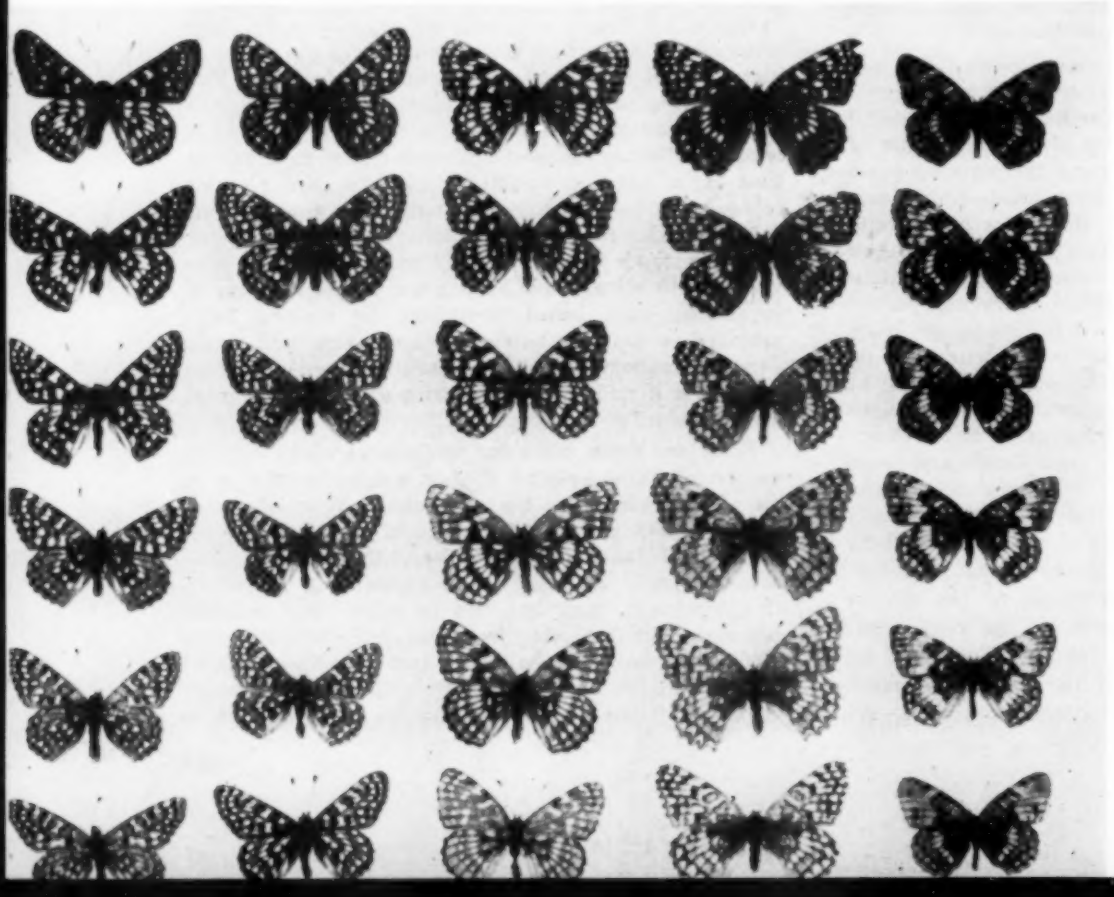
Such a direct relationship may actually exist in the case of some such color forms. For example, the close resemblance between a *melanic* (dark) moth and the smoky tree trunk on which it rests in industrial areas is in direct contrast with the light colored non-melanic moth and the light gray tree trunk free of smoke in non-industrial areas. One needs merely a *known predator* of these moths to complete the picture of selection against the unfit form in each environment. As the full expression of the color of the moth depends only upon a single pair of allelomorphic genes, the effects of selection will depend directly upon its severity; that is, the population will change fastest the greater the selection rate.

The simplicity of this theory is not a good reason for discarding it and for considering other possible means for a change of the population.

Resemblance (mimicry) between related forms of insects has also been judged as due to a fancied unpalatability of one form to a potential predator on both, the results being that the edible form, through selection, approaches the undesirable one in appearance for wholly protective reasons. On purely logical grounds, both these means for population change are reasonable.

Another theory finds predators unnecessary. Here, the point in question is the physiological adaptability of the insect to survive under the physical conditions of the environment in which it finds itself. The conditions that come to mind are temperature, light, humidity, rainfall, cloudiness, atmospheric dust and smoke, conditions affecting reflection of light, heat transfer, etc. This theory finds the greatest utility under natural conditions and

FIGURE 1. Parallel color variation in five species of *Melitaea* butterflies occupying diverse habitats ranging from the cool and humid north coast of North America (top) to the warm and dry southwestern desert (bottom). The range of variation within each species is controlled by multi-genic inheritance. From left to right the species are *M. chalcedona, M. editha, M. palla* and *M. hoffmanni.*



the broadest application to all insect life. The relation of color of the insect to each of these factors may be a direct one. That is, the black color of an insect under the bright sunlight of the desert may be deleterious, leading to overheating in the lethal range. Black, however, also may be distinctly *advantageous* to an insect in a fog-belt, or in an area of cold temperatures, as an aid to absorption of solar energy. Or, on the other hand, the relation may be indirect. For example, a gene that increases the rate of development would be of advantage to an organism needing a short life-cycle in arctic regions. Such an influence conceivably could be one of the many physiological effects of a gene which through alteration of growth rate would also alter some metabolic end-products, as for example, pigmentation.

Most characters concerned with parallel variation, including color variations, are controlled by many gene and allelic differences with the result that the variation observed in wild populations is continuous (Fig. 1). In such cases, the exact relation between the genes responsible and the environmental conditions, can not be determined. There are too many genes and too many environmental conditions to contend with. On the other hand, if the color variation were controlled by a single pair of alleles, and if these formed a gradient of different proportions in wild populations, it would thereby be possible to cut out one major source of difficulty in analysis. Such a possibility was found in the species of *Colias* butterflies.

Females of *Colias* butterflies are usually found to be polymorphic a pair of alleles controlling wing color, the dominant allelomorph giving white and the recessive yellow or orange (depending upon the species) in the female sex. The relative proportions of the two phenotypes, white and orange or yellow, change from location to location, and regular gradients of phenotype frequencies may be arranged. Within each species of *Colias*, the populations having the higher white frequencies are generally in the colder and more humid areas (Fig. 2) while the populations having the higher yellow or orange frequencies are in the hotter or dryer areas.

All species of *Colias* found in North America have comparable gradients of frequencies in relation to geographical location. Such a condition is hardly expected due to chance alone, and it was therefore logical that some reason be sought in order to answer the questions which naturally arise.

Tests of the relation between the color types and the physical factors of the environment are easier to deal with than any correlations having to do with biotic factors. Of aid in the determination of the physical factors responsible for the two color types was the simulation of part of the geographical climatic differences at different seasons of one year and at different times of the day in a single locality. For example, the low intensity maximum solar radiation of the higher latitudes is simulated each day early in the morning and late in the evening. Likewise, the low maximum temperature of the higher latitudes is also simulated each day in the south by the lower temperature in the morning and in the afternoon. This leads to the observation that if these physical factors of the environment were important, why should not their action be detected in a difference in *habit* at one location on the same day? Such a difference ought to be ap-

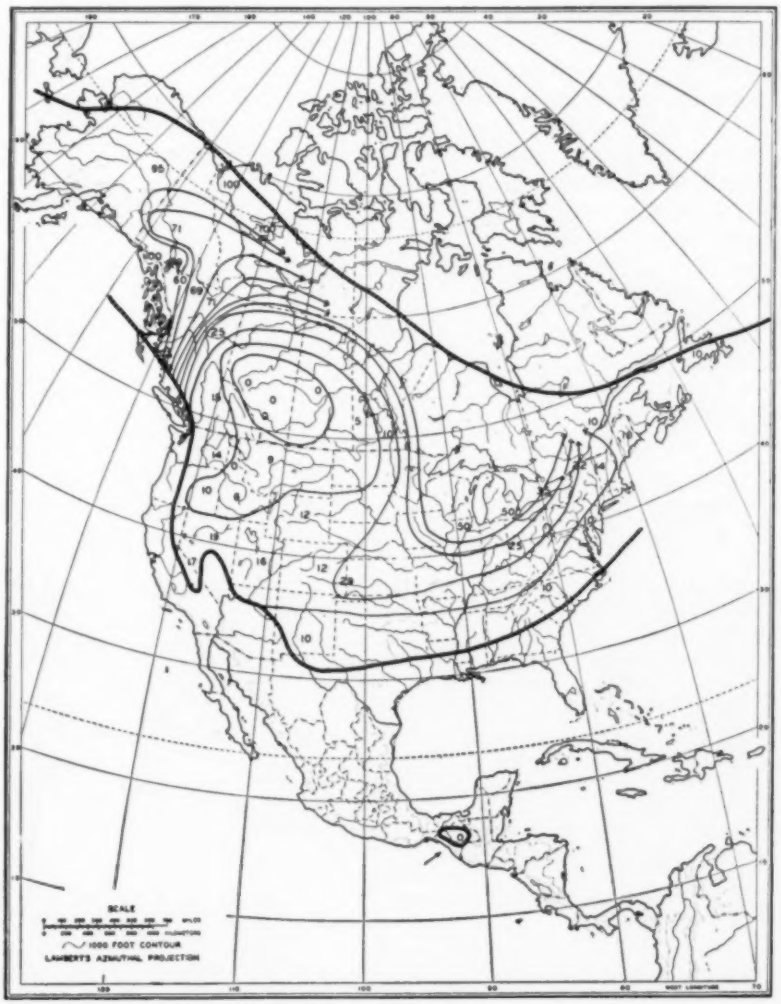


FIGURE 2. Geographical distribution of frequencies (in per cent) of white dimorphic females in *Colias philodice*. Highest frequencies as in most other species are in the northwest (Alaska) and other subarctic regions, decreasing toward the prairies and the plains but with secondary highs in the mountain areas of the far west and in the more humid Great Lakes and eastern regions. An indicated absence of the white phase for the prairies of Alberta and Saskatchewan is apparent for this species as well as *C. gigantea* and *C. interior*. On the other hand, a high white frequency (nearly 100 per cent) for Alaska is indicated for this species as well as *C. gigantea* and *C. palaeno*.

parent if selection is to act on changing the gene frequencies from one location to another.

Field tests were made of this hypothesis at two locations in California where *Colias eurytheme* was sufficiently common to give a statistically large series of hourly samples, namely, near Bakersfield in the San Joaquin Valley, and near Brawley in the Imperial Valley. The former location is about 200 miles north of the latter and is considerable cooler. The results bore out the hypothesis. The frequency of white females in the active white adults was highest in the early morning and decreased toward noon. An increase may or may not occur late in the afternoon. These results are shown in Figs. 3 and 4. It is noted that the minimum activity of the white females was reached earlier in the more southern location than in the more northern, coincident with the higher temperatures and higher solar radiation there.

Now what does this mean? I think that it means that the same factors of the environment which are active in bringing about population changes geographically as shown in the map (Fig. 2) are the same as those that are active in a single population each day. The activity of the adults as registered by the data show that the two color forms differ in the optimum conditions required for existence. Without activity, the butterflies cannot long survive as a population. Lower solar radiation and lower temperature in the morning lead to a proportionately greater activity of the white forms and therefore their contribution to succeeding generations through mating and egg laying is greater. At midday, their decreased activity correspondingly leads to a decreased contribution to the population.

How much these results with *Colias eurytheme* may be expanded to serve as a prototype for similar color-environment correlation remain to be seen. Each problem has its own special idiosyncrasies and where the answer to one may be in mimicry, with another it may be in such general conditions as have just been described. The true picture in most cases may actually be a combination of several different theories. There is ample room for much more work before we have the complete answer. ●

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"To regard science as a manifestation of evil; to regard it as an oracle to which all questions, both objective and subjective, may be appealed for an answer; to regard it as a near-deity or a criterion for moral law: these are the dangerous results of too little knowledge. Unless such attitudes can be effectively combated in general-science courses, scientists had best join medical men in a belief that knowledge of their subject should be reserved for those willing to devote their lives to it."

KONRAD B. KRAUSKOPF

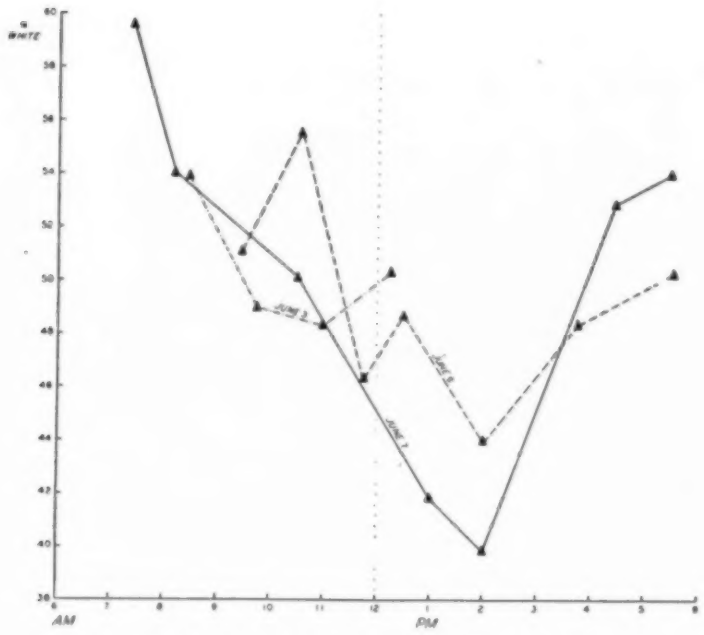


FIGURE 3. The frequencies of the white-phase females in an alfalfa field near Bakersfield, San Joaquin Valley, California, at different times during the three days, June 3, 6, and 7, 1946.

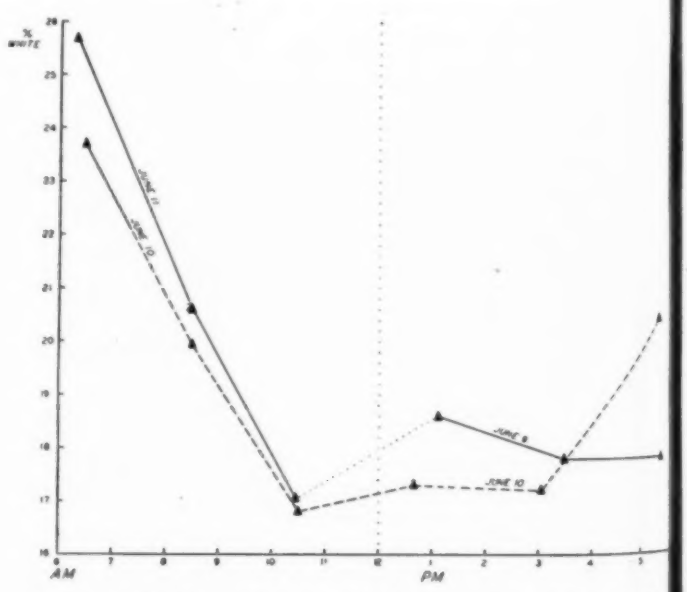


FIGURE 4. The frequencies of the white-phase females in an alfalfa field n Brawley, Imperial Valley, California, at different times during the three d June 9, 10, and 11, 1946.

Planning the Science Room from Within

● **By Warren J. Pelton**
GRADUATE STUDENT, SCIENCE EDUCATION, SCHOOL OF EDUCATION, STANFORD UNIVERSITY *AND*

James D. MacConnell
ASSOCIATE DEAN, AND DIRECTOR, SCHOOL PLANNING LABORATORY, SCHOOL OF EDUCATION, STANFORD UNIVERSITY

This article can be a life saver for the teacher who is planning, or helping to plan, a new science room. It will give pleasure and information, too, to the teacher who hopes to plan one.

Not infrequently, wasted space and congested areas are to be found in science rooms, even in those of recent construction. But the architect is not to be blamed if he did not receive in advance the proper educational specifications for the room.

Here is a brief story that tells how a satisfactory science room can be designed to meet the special requirements of those who will use it.

●

Modern schools place a great deal of emphasis upon developing the whole personality of the student. This results in a very important concern for the provision of situations wherein students have an opportunity to exhibit individual initiative, and also to work in cooperative enterprises with fellow students. The science classrooms should provide ample opportunity for both these types of activities.

Before any group of selected individuals can begin to plan the facilities for the construction of a modern science room, many important details must be taken into consideration. The old idea of constructing a science room and then adapting the curriculum to the available facilities, is definitely outmoded. The one primary objective in planning a science room should be to determine the activities which will be followed throughout the study of the course, and then decide which type of facilities will best accommodate these activities.

Lecture-Discussion

Practically every science course will include some lecture periods and some lecture-discussion sessions. This type of activity should, in turn, determine the type of facilities that will best accommodate this activity. When students are grouped closely together, and not spread all around the room, a more stimulating discussion can take place between the teacher and the students. Therefore there should be a space allocation within the room where the students can be assembled for this special activity.

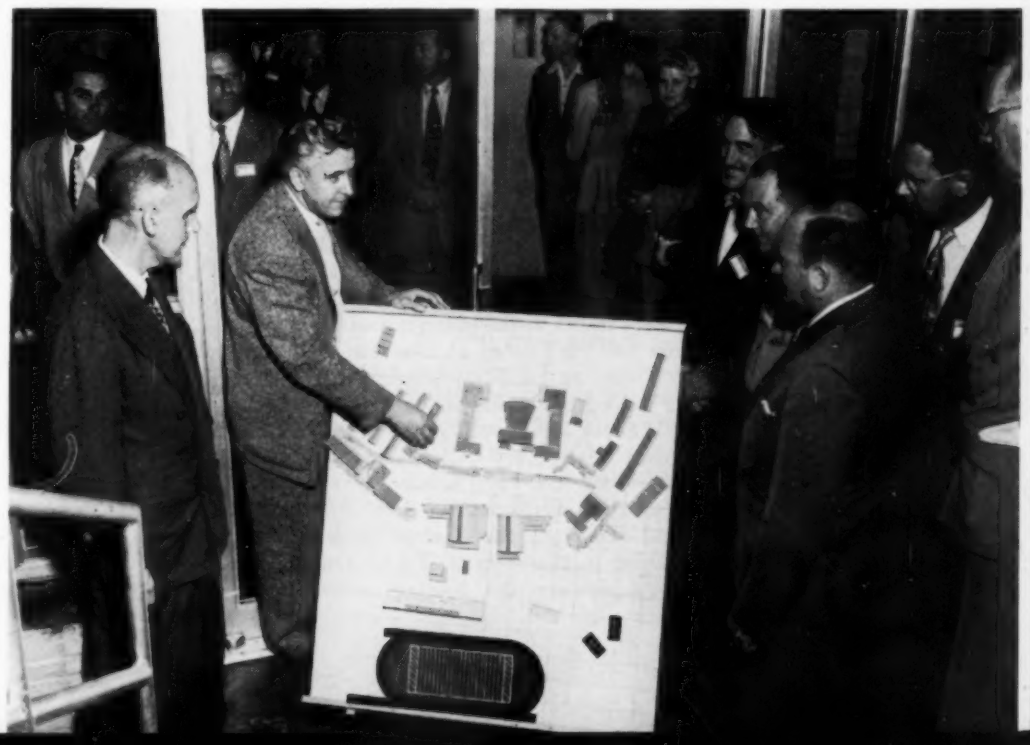
Teacher Demonstration

Closely allied to the lecture discussion period is the teacher demonstration. This activity calls for a fully-equipped demonstration table within the visual and auditory range of each student in the classroom. Care should be taken to have the students seated as close to the demonstration table as possible, and still be located so that no student is in the line of vision of another student. The demonstration table should be of such a height that the student's line of vision is focused directly upon the demonstration when seated in a normal position. This enables the student to see the demonstration being presented without looking up or down. Visual and physical fatigue is decreased when the students are able to observe the activities from a normal relaxed position rather than in a state of undesirable tension due to a poor seating arrangement. Correct seating can easily be obtained by having movable chairs located directly in front of the teacher's demonstration table.

Student Experimentation

The laboratory is the place where the students actually learn by doing. These laboratory facilities should

DR. J. D. MACCONNELL, Associate Dean of Stanford's School of Education and Director of the University's School Planning Laboratory, demonstrates a School Planning Board, designed by graduate students, to some members of the California School Trustees Association. (*Photograph taken at the entrance to the School Planning Laboratory.*)



be located in the same room as the lecture-discussion section. This facilitates the flow of traffic from the lecture area to the laboratory area, and decreases the time spent moving from one location to the other. During the laboratory period all the students may work on the same experiment or different students may work on individual experiments. This necessitates complete equipment on each of the students' laboratory tables in the chemistry and physics sections. Such equipment includes the following items: running water; AC and DC current; acid-resistant table top; gas jets; uprights and crossbars; hydrogen sulphide outlets for the semi-micro qualitative analysis sections; and acid-resistant sinks. Biology tables need not be equipped with more than sinks, running water, and electrical current. Equipping the tables in the foregoing manner enables all the students in the room to work on a profitable enterprise at the same time.

Regardless of whether the instructor uses individual experiments or group experiments, it is vitally important that the flow of traffic within the laboratory be free from congestion during laboratory time. Within the laboratory the visual field of the instructor should not be hampered by having some of the students' backs to him during experimentation time. The best possible arrangement would be to have all the students facing in the same direction, or to have all the students face the center of the room. The latter plan would demand a circular or U-shaped arrangement of the laboratory tables in the laboratory section.

Student Projects

Another important part of the science curriculum is the use of projects. Project work can be carried on by individuals, groups, or by the entire class. To facilitate these projects, there must be available floor space and tables arranged in a manner that will enable all the class members to observe the work being done on each of the projects. The space allotted to projects should be so located that the projects will not be disturbed when the students are not working on them. It is through the use of such projects that many of the principles of science come graphically to life. This type of class activity should also demand a certain amount of area for study and display of completed projects.

Use of Current Materials

The use of current materials is rapidly becoming an integral part of every science course. There should be ample tackboard space to handle the various pictures and articles which are obtained by the students and teachers and are pertinent to the material being studied. These tackboards will be located on the side wall near the front of the room to facilitate observation by the students during a lecture or discussion session. Additional tackboards could be placed on the rear wall for use during the time allotted for individual work. Tackboards in the front of the room should be used only for the specific daily presentation or they will tend to distract the students from the desired area of concentration. Included in the room would be a magazine rack which would contain the leading science periodicals and other related magazines. This rack should occupy an area that will facilitate its use by a number of students at one time.

Science Library

The science room should also include a special science library within the room. This library or book shelf would be large enough to hold at least a hundred or more copies of leading science textbooks and other related books of scientific information. Strategic location of this book shelf would enable several students to utilize the facilities at the same time. If possible, reading chairs for student use would occupy the area adjacent to the bookshelf.

Audio-Visual Materials

Because the use of audio-visual materials can supplement any phase of the modern science curriculum, the science room should contain facilities for decreasing the amount of natural light entering the room when movies, slides, or strip films are being shown. Many schools now successfully use the popular daylight screen for classroom presentation of films. The orientation of the students' seats should be that of locating all the seats within the 50 degree cone of best observation for films. When this limit is passed, visual and physical fatigue become apparent. The electrical outlets located in the walls and floor facilitate the use of the projection equipment, radios, television, and wire recorders. Television facilities should be taken into consideration because many educational programs are now being telecast for the benefit of the school children. The Federal Communications Commission will require that every town with three or more channels reserve one channel for educational purposes. Even though the area may not have television at the present time, such facilities should be available when television does come to the community. Electrical connections in the room and antennae locations and connections can be determined in advance.

Free Space

The modern science classroom demands some "free" space wherein activities such as the sociodrama and buzz sessions can be conducted. Many schools do not use these activities at the present time, but such activities are gaining more recognition all the time. Because of this, there should be a space allocation for these activities which will be practiced more extensively in the future. The "free" space can also be used for various types of experiments which cannot be conducted at the laboratory tables. Many experiments in mechanics can be performed here in the physics class, special demonstrations can be conducted for the biology students, and large projects can be erected in the chemistry and general science classes.

Location

The location of the science rooms with respect to the rest of the entire plant must be taken into consideration in the pre-construction planning. Because the science department works cooperatively with several other de-

partments such as the manual arts department and the home-making department, care should be taken to group these departments as conveniently as possible in order to facilitate the freedom of exchange of pupils and materials between these departments. Much can be done to aid this situation by locating the science rooms on the ground floor of the school and orienting the other departments accordingly. The ground floor location also aids the science department by permitting a free flow of traffic to and from the room during class periods. This means that the science class will be free to leave on field trips or go into the immediate area for firsthand science information without disturbing the rest of the classes in session in the school.

Lighting

The lighting of the science room definitely requires special consideration. This is brought about by the many different types of tasks and activities conducted in the science room. The orientation of the rooms and the type of fenestration should be selected to facilitate the various activities with the least amount of visual and physical fatigue. The contrast between a seeing task and the immediately surrounding surfaces should not exceed 1 to 3, and between the task and the more remote surfaces should not be less than 1 to 10. The background brightnesses should never exceed the task brightness or be less than the 1 to 3 ratio. There should never be less than 30 foot-candles on the task areas utilizing exacting work in the science laboratory. The lighting considerations also include those tasks that require distance perception, such as lectures and teacher demonstrations, as well as those activities that require exacting work.

Teacher Space

Special space allotment is necessary for the teacher to execute his personal work. This space would include filing cabinets for storing student data, a desk for the teacher, an area that can be devoted to guidance and counseling, and space for the teacher to store laboratory smocks and other personal belongings.

Storage Facilities

Adjacent to the science room will be a storage room that will hold all the necessary supplies for the course throughout the year. Within this storage room space will be allotted to the preparation of special materials and equipment necessary for class presentation. Some space must be designed to hold charts, graphs, and pamphlets when not being used as classroom displays. Another section of the storage room will include space for the construction and repair of science equipment. The last consideration for the storage room will be a specially constructed cabinet for the safe keeping of the audio-visual equipment.

Photographic Darkroom

Because many schools are now including special courses in photography in their curricula, a photographic darkroom should be constructed for use in collaboration with all the science classes in the modern secondary schools. This darkroom can be included in the science wing or can be located in proximity to the science rooms.

Planning

The plans for the modern science classroom should be so coordinated that all the foregoing activities can be accommodated to the best advantage of the student. In planning for these facilities, the school budget must be taken into consideration making possible the most convenient combination.

The overall planning of these facilities should include the science teacher, non-certified personnel, and often does include an educational consultant to work in close cooperation with the architect. The fundamental deficiency in the planning of science classrooms today is that the educational specifications are too limited. The educational specifications for a science classroom should include the number of students to be accommodated, the location of the science wing, with respect to the rest of the school plan, the types of activities to be carried on in these classrooms, the type of facilities required to best perform these activities, the relationship of the science section with other specific units of the school plant, and examples of typical classroom situations. When all this material is included in the educational specifications for a specific classroom, then a competent architect will be able to translate this material into sound construction practice. This will prevent wasted space in the room, and many of the congested areas that occur within the room primarily due to inadequate planning prior to construction.

It is evident that a great deal of consideration should be given to the current methods and practices of teaching in the field of science, making possible the best learning situations for the students. When the time comes that all phases of classroom activities are indicated by specific situations and examples in the educational specifications, then the science classrooms will be constructed to meet the needs of today and tomorrow, instead of yesterday and today. ●

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I, myself, believe that religion has still a very vital function to perform in our society. The eighteenth century idea that science is a cureall which can take the place of religion as a regenerative force in society simply doesn't fit with the history of the last two hundred fifty years. Moreover, it seems to me that the idea that the progress of science has made religion impossible for intelligent people is based on an overestimate of the accomplishments of science—as if the mysteries of the universe were already so fully explored that there is no room left for God outside the bright light of science.

EDWIN C. KEMBLE
Prof. of Physics, Harvard University

Science, Education and Society

● By **Alexander Calandra, Ph.D.,** *(New York University)*
THE PHYSICAL SCIENCES DIVISION OF THE BASIC COLLEGE PROGRAM, WASHINGTON UNIVERSITY, ST. LOUIS, MISSOURI

The progress of science has corrupted man.— *Rousseau-1750*

Science in itself is not evil, but it may have evil effects.

Can the agencies responsible for the ethical and moral structure of society counterbalance the strains that are set up by the continuing progress of science? What part does science education play? Are teachers so involved in teaching scientific techniques related to technological processes that the basic needs of the student, the community, and mankind are forgotten? Will a more careful training of science teachers and a lowering of the demands for many courses in education help the situation?

Dr. Calandra's ideas on these and related matters will challenge your thought.

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In the early part of this century there was a demonstration of a mechanical device that had been recently invented. The device was a heavier-than-air vehicle that could move through the air under its own power; it was called an airplane. As part of the demonstration, the vehicle was flown over the heads of the spectators who gave it a tremendous ovation as it went by. Shortly afterwards the crowd dispersed leaving behind only one spectator who seated himself on a bench and held his head in his hands while tears streamed down his cheeks. When a passerby asked if he were ill, the lone spectator replied that he was only thinking of how short a time it would be before some one would build a larger airplane and put a cannon in it to kill people.

This incident took place a long time after Rousseau had defended the thesis expressed in the quotation. Rousseau did not discuss airplanes when he took this position; in fact, his ideas were put forth in an essay submitted for a prize offered by the Dijon Academy for the best answer to the genteel question, "Has the progress of the arts and sciences contributed to corrupt or purify manners?" Nevertheless, it is clear that if Rousseau had been at the demonstration he would have been a crying spectator.

Science, of itself, is not an evil thing and no one says it is, but in Rousseau's time its evil *effects* were probably greater than its good ones. Science had contributed to the development of the art of warfare; it had led many people to misinterpret the basis of religious faith, and it had already begun to suggest methods of production that encouraged the exploitation of human beings. Science had not as yet lessened the possibility of famines, checked the spread of epidemics, or given large numbers of people the leisure and means for education.

In the 19th Century and the recent part of the 20th, the effect of science was somewhat more beneficial to humanity. Many infectious diseases had been almost completely eliminated; fertilizers had made the earth more productive; new methods of communication pointed the way to a world brotherhood of mankind; and the future of humanity seemed to be one of unlimited promise.

The crying spectator introduces the third period in the story of the effects of science on the welfare of humanity. Here, as never before, science begins to turn the plough into the sword, means of communication into means of deception, the power to build to the power to destroy, and the philosophy of hope into the philosophy of despair. How did this come about? How can it be changed?

Some light is shed on these questions by comparing the situation which gave rise to them with a situation which gave rise to a theory in economics which was generally popular in the 19th Century. At that time the Rev. T. R. Malthus reasoned that since the population tended to increase more rapidly than the food supply, a starved society was inevitable unless some agency intervened.

If we examine the effects of an increase in the progress of science, we note something analogous to the effects of an increase in the population. It produces, in the organization of the society, a disturbance which arises in large part from its increasing complexity; the latter in turn produces an increasing strain on the ethical and moral resources of the society. In other words, this situation suggests a "Malthusian Theory" in which science and ethics, instead of population and food, are the opposing forces. This highlights the fundamental problem of modern society; that is, can the agencies responsible for the ethical and moral structure counterbalance the strains set up by the progress of science? If there is no adequate answer to this question, then we shall see the Genie who has come out of the test tube destroy the people who called him forth.

The dire effects predicted by the original Malthusian theory have not yet come to pass. Despite the enormous growth in the world population there is probably proportionally less starvation now than there was at the time of Malthus. This came about simply because the food resources of the world turned out to be more plentiful than Malthus could have predicted. Can we hope for a similar outcome in the science-ethics problem? Do we have unsuspected resources in the agencies responsible for the moral and ethical structure of society?

The agencies which produce and maintain the ethical structure of our society are many: the family, religion, education, business and government all play an important role. If these institutions cannot cope with the problems, and there are none to take their places, the problems are hopeless. When family ties are weak, religious influences missing, educational processes decayed, business practices unenlightened and government structures corrupt, it will follow that progress in science represents progress toward disaster. If, however, these agencies are ready and willing to undertake the responsibility of directing the development of the moral structure of society to meet the challenge, then progress in science will represent progress toward a world where human living is worth while.

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The special interest of the science teacher in this connection is, of course, in educational processes. What is there in education, especially science education, that can be significant in this situation?

As far as education as a whole is concerned, the process is excellently adapted to a living example of the manner in which people can get along together with complete respect for human dignity and the democratic process. In an educational process which is decayed, the teacher forgets that the student is a human being and seeks to obtain results in terms of a pattern of fears and pressures which is quite analogous to totalitarian systems of government.

As far as education in science is concerned, the major benefits would seem to be derived from an understanding of the physical and biological environment and an appreciation of how this understanding came about. Unless this is done, however, in such a way as to enable a student to develop a constructive attitude toward the kinds of behavior he can exhibit, and types of satisfactions he can find in the actual world he lives in, much of this effort is wasted. Unfortunately science is not usually taught in this fashion. Most of us are so involved with the teaching of scientific techniques related to technological progress, or with the satisfaction of perfunctory science requirements, that the basic needs of the student, the community, and mankind are almost completely forgotten.

In the reorientation of the teaching of science to produce the recommended goals we are confronted with a number of serious obstacles. The most serious of these is the present method of training science teachers. It is now next to impossible for our new recruits in the field of science teaching to obtain a respectable knowledge of science or methods of teaching in our present institutions. Science departments, because of their serious concern with research, do not usually have time to handle this problem; education departments are very seriously handicapped by lack of adequate staff for this kind of work. The inevitable results of this situation are the poorly trained teachers who, in spite of the best intentions and the greatest enthusiasms, are incapable of doing much about a fundamental approach to the teaching of science.

The above difficulties suggest two lines of approach. The first approach is the encouragement of science departments to develop a real interest in devoting some of their resources to an earnest and sympathetic effort in the training of science teachers. This must take into account the fact that the teachers preparing for high school and elementary work do not usually have the background and time that is available to pre-engineering and pre-medical students. At present, student teachers are justifiably afraid of college science courses since it is their experience that such courses, as now organized, represent a tremendous amount of effort on their part with little functional return and a substantial risk of failure as a result of competition with students with professional science interests. To escape this possibility the student avoids college science courses and embarks on a career of education courses which, although often of as little value to him, are at least usually conducted in an atmosphere of greater sympathy.

The second approach is the freeing of teachers from the necessity of taking large numbers of courses in education in preparation for science teaching. The reason for this suggestion is sufficiently well known not to require extensive comment.

Unless the universities and teacher training colleges follow both of these suggestions the prospective science teacher will be constantly taking courses in which he is almost certain to be bored or to do poorly. Neither type of course does much toward making him the kind of science teacher that our society now needs. Both choices produce a frustration and resentment that too often reappears in his attitude toward his own students.

The situation outlined is not, of course, true of all universities and teacher training colleges. Some of the more alert institutions are seriously attempting to remedy them, but unfortunately there are too few institutions that are in a position to do so. To bring about a substantially healthier situation may require the support of philanthropic institutions which are better insulated against the decaying processes which have affected some of our educational programs. Such support, together with the earnest cooperation of the educational institutions themselves, should go a long way toward resolving the paradox which Robert Lindsay summarized some years ago in a Sigma Xi lecture:

> "The great paradox of our civilization is the failure of man as a moral, spiritual, and ethical individual to adjust himself adequately to an environment radically altered by the applications of science. This adjustment will come but only by a slow process of evolution which will put a decided premium on our patience. It will come when the method of science makes as great an impact on the thoughts of men as it has made on their external environment." ●

Oysters in the Shell as Living Laboratory Animals

● By G. Francis Beaven, M.A., *(Duke University)*
MARYLAND DEPARTMENT OF RESEARCH AND EDUCATION, THE CHESAPEAKE BIOLOGICAL LABORATORY, SOLOMONS, MARYLAND

Help for the biology teacher—especially the inland instructor who finds it difficult to demonstrate live marine animals. He may have overlooked the possibility of using oysters as a type form of mollusk to illustrate typical structures and special adaptations to environment.

Live oysters are easily available, they offer few difficulties of handling, and they are a renewable natural resource of economic importance.

In this well written article you will learn things about oysters that you probably never knew.

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The liveliness of the instruction in a biology class often can be gauged by the amount and variety of living material which the student is given opportunity to handle and observe. Charts, models, and preserved specimens are valuable aids and should not, of course, be abandoned. Dead indeed, however, is the quality of teaching which depends entirely upon such aids to supplement the lecture and text book.

For effective demonstration of response to stimuli, and of the normal functioning of organs, the use of living plants and animals is essential. Observations need not be limited to a few stereotyped forms but should be as varied as possible and include living material which not only is interesting to the student but is significant to man's welfare. In providing and caring for such material, lack of funds and facilities are handicaps which often must be met by the ingenuity of the instructor. Frequently, most specimens are obtained from nearby fields, forests and streams and are supplemented by exotics wherever opportunity for their collection or acquisition may permit.

Seldom, however, do inland classrooms demonstrate live marine animals, although forms of this type constitute a major part of the world's fauna and many of them are of great economic importance. As human populations grow and land resources shrink, there is real need for greater familiarity with those denizens of the sea that supply in no small measure man's need for food. Such understanding is all the more important in that these forms constitute renewable natural resources upon whose wise management much of man's future well-being may depend.

FIGURE I. Semidiagrammatic Sketch of an Oyster (Dissected in left valve) a. Adductor muscle; b. Anterior end; c. anus; d. Auricle; e. Anterior aorta; f. Dorsal aspect; g. Gills; h. Hinge ligament; i. Intestine; j. Liver; k. Mantle; l. Nerve; m. Mouth; n. Oesophagus; o. Palps; p. Pericardial cavity; q. Posterior aorta; r. Posterior end; s. Reproductive glands; t. Shell; u. Stomach; v. Tentacle; w. Ventricle; x. Ventral aspect. (from R. V. Truitt, *"The Oyster."*)

Today, as a result of modern means for supplying fresh food in variety to American homes, it is possible for the resourceful teacher in almost any part of the country to obtain several species of live marine creatures at some nearby market. Most common among the forms available are oysters and clams in the shell, live lobsters in closed containers, and, at points not too far from sources of supply, both hard and soft shell crabs. Of these, the oyster has been selected as the subject of this paper to illustrate some of the interesting aspects of its use as a laboratory animal.

Students and teachers in schools located at or near

our oyster producing centers enjoy a unique opportunity to visit this interesting industry in all of its phases and to bring back to their laboratories a wealth of material for study. Through wider dissemination of knowledge concerning the life history and habits of the oyster, and through a better understanding of the complex problems involved in its management, rapid strides could be made towards wiser use of this valuable natural resource. It should be the special obligation of schools located in oyster producing areas to help bring this about. Their studies of the oyster can go far beyond this presentation and should deal with the social and economic problems of the fishery in addition to its biological aspects.

The oyster, of which the eastern oyster, *Crassostrea virginica*, will be considered the type, is a rather hardy marine creature which can maintain a water-tight closure of its two heavy valves or shells for long periods. When thus closed it is protected from most carnivores of the sea and from desiccation when in a position of exposure at low tide. Oysters may be frozen and, even though subjected to temperatures below the freezing point, when thawed without changing position are able to resume a normal life. Frozen oysters that have been jarred or otherwise disturbed usually die after thawing. Oysters out of water will keep best if they are stored in a cool moist place, protected from drying air currents, and placed so that the more deeply cupped left valve is underneath and in a horizontal position. The reason for this is that the oyster occasionally relaxes the muscle that maintains its shell closure. At such times some of the liquid enclosed in the shell cavity may drain out or be evaporated by air currents. When properly stored, oysters can be kept alive for weeks or even months. One company which specializes in high quality raw bar oysters claimed that a barrel of their oysters, stored at just above freezing, was kept from December to March and the oysters replanted with very little loss. During that period they continued to be of good eating quality.

Oysters obtained for laboratory use from a raw bar or sea food market should be as fresh as possible and in good condition. They may vary quite a lot in size and shape and in the number and kind of other organisms attached to them. Experienced men in the oyster industry often can tell at a glance the area from which a group of oysters originated, and local watermen can even name the particular bar or reef. Typically the oyster will have the left valve more deeply cupped and may show near the hinge, at the narrow end of the oyster, an area where the oyster was attached to a shell, another oyster, or some other firm underwater object.

The shells of an oyster are interesting objects in themselves. Often they tell the story of the oyster's competition with other creatures, its survival from enemy attempts to penetrate its armor, its age, rate of growth and even the changes of position it may have undergone when disturbed by some outside force. Shortly after the young oyster attached itself to a shell or other object it began to grow upward and outward towards free circulating water from which it must obtain its food. Layer upon layer of new shell was added throughout the inner surface of its shell and the shell margins were extended more greatly in a direction away from the hinge. Seasonal changes produced variations in the rate of growth so that irregular ridges were left on the outside of the shell as new growing edges were laid down. From the more prominent of these an experienced person can, in many cases, estimate the oyster's age.

Oysters that have grown rapidly have thin sharp growing edges or "bills" while those which grew slowly are blunt and thick. If the oyster was moved in the course of its growth, or came in contact with other oysters or firm objects, then it probably changed the direction of its new growth. This can be clearly seen if such an individual is among those observed. As the shell increased in length the large adductor muscle which holds the shells closed migrated away from the hinge end in order to gain increased leverage. Where this muscle is attached, the shell typically is bluish in color. By cutting an oyster shell with a hacksaw lengthwise through the muscle scar the migration of the muscle away from the hinge can be traced clearly, as is true of a series of distinct growth marks.

The shell of an oyster sometimes may present what amounts to a menagerie of other marine animals. Barnacles, small mussels, key hole limpets, *Crepidula*,

OYSTER DREDGE BOAT

Formerly over 1200 such vessels engaged in dredging oysters from Maryland waters. Now approximately one-tenth of this number work the depleted bay oyster rocks. (from G. F. Beaven, *"Maryland's Oyster Problem."*)

sea squirts, sea anemones, sponges, hydroids, tube building worms, and encrusting *Bryozoa* are often among those present on the shell's surface. In crevices or burrows in the shell may be found annelid worms, tiny mud crabs, isopods, amphipods, boring sponges and even boring clams. Small neat round holes made by the oyster drill, another mollusk, in attempting to penetrate the shell often are visible. The mud or slimy film adhering to the shell is rich in marine diatoms and other forms. The number and variety of these organisms to be found will depend largely upon the source of the oysters and the extent to which they have been cleaned. Many of the associated organisms will be dead if the oyster has had long exposure out of the water since most of them lack the oyster's hardiness. Within the protection of the oyster's closed shells, however, living specimens of pinnotherid crabs will sometimes be found and annelid worms of the genus *Polydora* may occur in mud blisters covered by a thin layer of shell in the newly opened oyster.

If sea water is available at the laboratory the oysters may be immersed in it, left valve down, where they will survive for many weeks. They usually thrive best in water about two-thirds as salty as the open ocean, for their normal habitat is in the brackish estuaries of the coasts. Before placing them in an aquarium dead organisms on the shell surface should be removed as thoroughly as possible. Natural sea water is needed if the oysters are thus to be kept alive, and they must not be crowded in the container. However, it is often possible to observe some of the oyster's responses for a short period by substituting an artificial sea water of about two per cent salt. In its natural habitat the oyster lies with its shells slightly opened most of the time. If finely suspended particles are added to the water, a current expelled near the end of the dorsal margin opposite the hinge can be observed when the animal is feeding. Periodically the oyster will close its shells abruptly to expel accumulated undesirable or unacceptable materials. A thread cemented to the right valve and attached to a kymograph will provide an interesting tracing of the oyster's shell movements. A sharp rap on the side of the aquarium will cause immediate closing of the shells as will touching the oyster or injecting irritating chemicals in the water near its shell margins.

The oyster is an excellent illustration of the lamellibranch mollusks so well adapted for life on the bottom. As such, their structures may be studied in as great detail as the instructor may desire. Complete descriptions may be found in a number of texts dealing with invertebrates. The accompanying illustration shows the gross structure and will be sufficient for most purposes.

The live oyster should be opened carefully. Unless one is familiar with the use of an oyster knife of the type used by commercial shuckers, it may be well first to chip away a portion of the shell at the thin end or bill by striking it with a hammer. A long thin bladed knife then can be inserted and should be worked in with the blade pressing constantly against the inner surface of one of the valves. When it is far enough in to reach the adductor muscle this organ should be cut, still keeping the blade against the inner shell surface to prevent injury to the body of the animal. After cutting the muscle the shells must be pried apart so as to break the hinge ligament. When partly opened it is well to look between the shells to be certain that the animal is entirely free from the valve from which the muscle was cut. Otherwise the soft body may be torn.

The oyster on the half shell is still alive and may remain so for some hours especially if it is kept moist. Cutting the muscle causes considerable shock but does not result in excessive bleeding. A number of interesting observations may now be made. Within five or ten minutes after being opened, a number of the oysters should show regular pulsations of the heart. The thin pericardial membrane covering the heart, if unbroken, may be cut away to show this more clearly. Along the margin of the mantle are pigmented tentacles which serve as sense organs. By touching these with a needle a distinct retraction of the mantle can be observed. The mantle can then be folded back and the gills and palps examined. Sections can be made to show the stomach and other internal organs.

One reason for the oyster's great significance as a source of food is the fact that it feeds directly on plankton, the microscopic plants and animals which drift aimlessly about and form the basic source of nearly all food production in open waters. By means of its gills a large active oyster may pump as much as 50 liters of water in an hour and efficiently gather from it the food organisms which it needs. The mechanism of the gills by which this pumping is done can be made an interesting demonstration. Each gill may be described roughly as a V-shaped trough with its sides in accordion-like crosswise folds. A number of partitions divide it up into little sections or water tubes. Thousands of tiny pores through its walls permit the passage of water between the outside and the inner chamber. The gill's surface bears countless cilia which, by waving in unison, cause water to pass in through these pores. Special rows of cilia gather up and pass food particles, entangled by mucus, to the margin of the gills and thence up to the palps and on to the mouth near the hinge end. By cutting a small portion from a gill and mounting it in sea water or in a drop of water taken from the oyster's shell cavity the rapid beating of these cilia can be observed under a misroscope. If a strobilized light source is available the rate of beating can be measured and the effect of various substances added to the water can be observed.

If live oysters are studied between late spring and early fall, many of them will show well developed gonads. These appear as creamy layers of tissue just beneath the mantle, one on each side over the fleshy part of the animal's body. They consist of myriads of tree-like tubules which are filled with a milky fluid. By stroking with a knife from the hinge towards the muscle, the sex products can be forced out as milky drops which appear near the muscle or they may be collected by making a shallow incision across the gonad tissue. When these drops, termed milt, are mounted

(Continued on Page 34)

The Production and Use of Refrigeration at Extremely Low Temperatures

• By **S. C. Collins, Ph.D.,** *(University of North Carolina)*
DEPARTMENT OF MECHANICAL ENGINEERING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Will it ever be possible to produce temperatures below absolute zero, that is, 0°K? How closely has this temperature been reached? By what methods are low level temperatures obtained, and why are they sought? Do they have important theoretical and industrial applications?

Dr. Collins' lucid discussion of the "cold" question provides excellent background information for the teacher of science. It may perhaps attract the attention of the advanced student to a field that is to him new and different.

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There is no apparent upper limit to the temperature which may ultimately be reached. For a long time no clearly defined lower limit existed. The first hint that possibly there might be a lower limit came with quantitative measurements of the pressure-volume-temperature relationships of gases. 273 cc. of gas measured at 0°C was found to shrink under constant pressure to 272 cc. at −1.0°, to 271 cc. at −2.0° and so on so that the volume might be expected to become zero at −273°C.

The broadening scope of the field of thermodynamics of a century ago led eventually to the thermodynamic scale of temperature which is used for all present-day scientific measurements. This scale is based upon the performance of a perfect heat engine. The heat engine receives a quantity of heat, Q_1, at a thermodynamic temperature of T_1, converts a portion into useful work and discards the remainder, Q_2, at a second temperature, T_2. According to the thermodynamic or Kelvin scale the two temperatures are related by the equation

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}.$$

In order that the engine might convert all of the heat into work (in which case $Q_2 = 0$) it would be necessary that T_2 be zero. By so defining our temperature scale we have eliminated the possible existence of temperatures below 0°K. Accepting the value of one degree on the Kelvin scale as being equal to one degree on the Centigrade scale it can be shown that the absolute zero of temperature on the thermodynamic scale (0°K) is the same as −273.16°C. Although this number is subject to revision as the precision of pertinent measurements is enhanced, it is extremely unlikely that it will ever be changed by more than a few thousandths of one degree.

Some of the milestones on the road to lower and lower temperatures are as follows:

Boiling point of Oxygen	90.2°K	(1877)
Boiling point of Hydrogen	20.4	(1895)
Boiling point of Helium (1 atm)	4.2	(1908)
Demagnetization of Gadolinium sulphate	.25	(1933)
Demagnetization of Chromium-potassium alum	.004	(1935)

Because so large a fraction of the scientific effort expended in the field of low temperatures has been devoted to methods and apparatus for securing low-level refrigeration, a brief account of the methods is presented here.

An ordinary mechanical refrigerator contains three important elements: an evaporator which is very cold, a motor-driven vapor compressor, and a condenser which is rather warm. The three are connected together with pipes to form an airtight system in which a liquid refrigerant such as ammonia, freon, or sulphur dioxide can be circulated.

When a liquid evaporates it absorbs a relatively large quantity of heat. When the vapor so formed is caused to return to the liquid state by condensation, heat is given back to the surroundings. In the refrigerating system it is the purpose of the compressor to bring about continuous evaporation of liquid within the evaporator which is placed within the space to be cooled, and continuous condensation of the vapor in the condensor which is placed outside of the cooled space so that the heat may be carried away by the air or by a stream of cooling water. It has been found by experiment that the vapor pressure of any liquid increases rapidly as the temperature rises. In a refrigerating system, therefore, the pressure of the vapor rising from the evaporator must be increased by compression to the value existing in the warm condenser. The lower the temperature of the evaporator the greater the power required to effect a given rate of cooling.

For such temperatures as 40°F to −50°F, the range of commercial importance, the refrigerator described above is highly efficient. It loses in efficiency rapidly, however, as the required level of refrigeration goes down. Any refrigerant which can be condensed under reasonable pressures at room temperature will exhibit such low pressure in the evaporator at −300°F (88.7°K) for instance, as to render impracticable the step of compression. On the other hand if a refrigerant is chosen whose volatility at −300°F is sufficiently high to give the vapor a reasonable density, then the pressure required to effect condensation at room temperature is excessively high or, more likely, condensation can not occur at all.

For such low temperatures a different system of refrigeration is indicated. The earliest successful method consisted in utilizing the very slight cooling effect which nearly all gases exhibit when they are allowed to expand from a highly compressed condition into a

state of much lower pressure. This is known as the Joule-Thompson effect. The amount of refrigeration secured per pound of gas circulated is small compared with that derived from the evaporation of an equal weight of liquid. It is necessary, therefore, to practice great economy in its application. Not only must the cold enclosure be well insulated, but the refrigeration possessed by the cold expanded gas by virtue of its specific heat and low temperature must be recovered almost completely.

The device by which this is done, a counterflow heat exchanger, can be almost 100 per cent effective. It may be made of two long lengths of metal tubing of unequal diameters, the smaller tube being drawn inside of the larger one. Such an assembly affords two passages for carrying streams of gas. The highly compressed gas flows in one direction in the small centrally located tube.

The expanded gas flows in the opposite direction in the annular passage surrounding the smaller tube. The incoming warm stream of compressed gas is cooled by indirect contact with the cooler expanded gas traveling outwardly. By the time it reaches the warm outer end of the heat exchanger the cold expanded gas has been effectively robbed of its cold.

Gases exhibit an inversion temperature in the Joule-Thompson effect. For a given set of pressures there is a heating effect at temperatures above the inversion temperature and a cooling effect at temperatures below the inversion point. For air the inversion temperature is high above room temperature but for helium and hydrogen it is very low. These gases, therefore, are not acceptable as refrigerants if one must start out at room temperature.

Although the more efficient principle of refrigeration at very low temperatures described below has been developed, the Joule-Thompson effect is still much used in the production of commercial oxygen. Air is liquefied and distilled in fractionating columns which operate at about −300°F. Highly compressed air (800 to 1200 pounds per square inch), led through a three-passage counterflow heat exchanger, is expanded through a valve and thereby cooled. After separation in the column the nitrogen and oxygen flow out through separate channels in the heat exchanger.

If the compressed air is compelled to do external work while it expands just as steam in steam engines or turbines, a much greater cooling effect is secured. The air engine and air turbine are very similar to their steam driven counterparts, but because of the temperature at which they generally operate there are special problems of lubrication. The counterflow heat exchanger is still a necessity but because of the larger temperature drop in the expanding gas resulting from the flow of energy in the form of work, operating pressures for oxygen production fall from the order of 1000 pounds per square inch which is required for the Joule-Thompson process to the order of 150 pounds per square inch.

Industrial oxygen and nitrogen are produced at the rate of thousands of tons per day and constitute the most important application of low-level refrigeration. Pure oxygen is used in the steel industry, in chemical industries, for welding and cutting of steel, and for breathing. Nitrogen is used in the manufacture of fertilizers and explosives and as an inert atmosphere. Of equal or greater importance, however, is the tremendous research program now under way all over the world but principally in the United States, Great Britain and Holland. The behavior of all sorts of matter at extremely low temperatures is the subject of large scale investigation. The interest derives partly from the investigators' scientific curiosity and desire for a fuller understanding of nature, and partly from the promise of usefulness of such information in making possible new technical achievements.

Many of these studies demand the lowest attainable temperatures. By the use of helium as a refrigerant in the necessary apparatus which would consist of a compressor, counterflow heat exchanger, and an expansion engine, it is possible to reach a temperature of 4.2°K which is the boiling point of liquid helium under a pressure of one atmosphere, that being the lowest convenient pressure available in such a refrigerating system. If liquid helium is transferred from the refrigerator to a well-insulated air-tight container in which the pressure can be reduced by pumping, the boiling point of the liquid helium is reduced and the body of the liquid acquires the lower temperature by partial evaporation. A temperature of 1°K can be easily reached in this manner.

To attain still lower temperatures one resorts to magnetic cooling. Certain paramagnetic salts such as iron ammonium alum and potassium chrome alum possess the required magnetic susceptibility and heat capacity to exhibit at about 1°K a substantial rise in temperature upon exposure to a strong magnetic field and a substantial fall in temperature when the magnetic field is removed. When such a salt is kept in thermal contact with a 1°K bath of liquid helium during magnetization, so that the heat of magnetization is carried away by the boiling helium and the temperature remains at 1°K, then thermally isolated from its surroundings but still kept in the magnetic field and finally demagnetized, its temperature will fall to a very low value. A temperature as low as 0.003°K has been reached by the magnetic method.

Some of the Results of Low Temperature Investigations

Metals in general become stronger as the temperature falls, sometimes two or three times as strong as at room temperature. Along with the increase in strength comes an increased sensitivity to shock and to notches or imperfections in the metal. Iron and many of its alloys become very brittle and may be shattered by a blow. Below a certain critical temperature which varies with the composition and treatment, a specimen in tension will break with no reduction in area. At even a few degrees above this temperature the properties are so changed that considerable elongation with its attendant reduction in cross-sectional area (about

(Continued on Page 33)

Synthetic Detergents

• By **John W. McCutcheon**
CONSULTING CHEMIST, NEW YORK, NEW YORK

Soap has been used as a cleaner for centuries, but during the past decade modern synthetic detergents have stolen much of its market.

In this paper you may learn why soaps clean, and how the knowledge gained in their study was applied to the development of the new cleansers that have found a large and growing use in the dyeing and cleaning of textiles, in cleaning metal surfaces, in washing streets, and as domestic cleaners.

Since basic materials are cheap and manufacturing processes are not too involved, further extension of the use of these valuable products is to be expected.

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It is hard to say just when synthetic detergents were born. For one type we might set the date at 1898, another 1916, and for a third at 1925. At any rate before 1930, such products were considered curiosities. There was no production in America. Although the development is world wide, the most spectacular growth has taken place in America, chiefly because of the tremendous production facilities available. By 1940 about one pound was sold in America to every twenty pounds of soap. Today the ratio is about one pound of synthetic to every two pounds of soap. This tremendous growth of production is principally confined to the postwar years.

Certainly such products must have something spectacular to offer. To understand just what this is, we must give soap itself a bit of critical examination. In general, soap is a mixture of the alkali salts of fatty acids. Its history goes back to Biblical times where the alkali produced by leaching ashes was reacted with fats from various sources. Down through the years the art progressed until we had soap in many forms, as liquid, paste, bars, flakes and, more recently, as powders. No one thought a substitute could ever be made as cheap or as efficient as soap.

It took a long time to discover just why soap was such a good detergent. Even today certain points on this matter are still not well understood. The long hydrocarbon chain of the fatty acid is oil soluble. The alkali-neutralized head or carboxyl group is water soluble. The following formula of sodium laurate illustrates this.

$$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—COONa$$

tail ⟵ ⟶ *head*

For convenience this is often abbreviated to R—COONa where the R stands for CH_3-$(CH_2)_n$- where $n = 10$ in the example above.

Such compounds will orient themselves at liquid surfaces, and that is the reason why soap lowers surface tension and foams. In addition, soap molecules have a tendency to form into groups called micelles. These enhance the action of single molecules. Thus a soap solution can cause the liquid to penetrate into the fiber or crevices of the skin, loosen the dirt, and hold it in suspension until washed away in the rinse. Soap has two typical drawbacks however. First, the majority of its salts, other than the alkali metal ones, are insoluble. If a soluble salt is present such as magnesium sulphate or calcium bicarbonate, found frequently in hard water, the soap is precipitated thus:

$$2(R\text{-}COONa) + MgSO_4 \longrightarrow Na_2SO_4 + (RCOO)_2Mg \downarrow$$

The loss of soap is not so important as is the fact that the heavy metal salts are greasy and adhere tenaciously to any surface they contact. In scouring a textile, for example, preparatory to dyeing, small amounts of calcium, magnesium, or iron soaps formed from these salts in the hard water will deposit in spots on the fabric and make it impossible to dye the cloth evenly. The only way this can be avoided with soaps is to use soft water. This is an expensive handicap.

The second important point, is the fact that the fatty acids are water insoluble. For example:

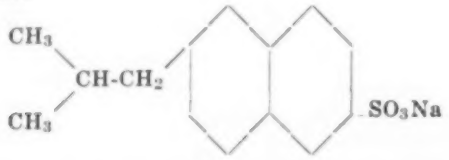
$$R\text{-}COONa + HCl \longrightarrow RCOOH \downarrow + NaCl$$

The free fatty acids are also sticky, gummy substances which coat fabric or metal surfaces and contaminate them. The soap itself is completely destroyed. This means that soap cannot be used in an acid bath. Of course, for general cleaning this is no drawback since no one washes his hands in acids! Industrially speaking, however, this is a handicap. Textile acid dye baths frequently are improved by the addition of a detergent.

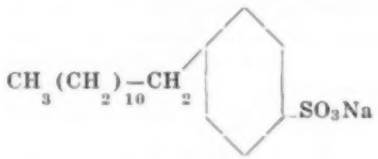
Thus it is seen that drawbacks of soap were first evident in the industrial field and the textile industry in particular. The chemist by this time knew some of the factors which must be solved in order to make a synthetic type soap product. He also knew that if he succeeded, his chances of making a product better than soap would be very good. Synthetic methods lend themselves readily to a wide variety of products.

The first commercial success came about 1916 when an alkyl naphthalene was sulfonated. The alkyl group

was small, usually isobutyl, so that the product looked like this.



The carboxyl group was substituted by a sulfonate group, which became the water solubilizing portion of the molecule. The hydrocarbon part of the soap chain was isobutyl naphthalene. Isobutyl is derived from a hydrocarbon and is called an alkyl group. A single six-membered ring compound or double ring compound such as benzene or naphthalene can become an aryl group. Thus, the product shown may be called an alkyl aryl sulfonate. This product was not a good detergent. For one thing it was too water soluble. Years of study since this first product was made have revealed that the best detergents are made when the ring compound, such as the naphthalene, is reduced in size to a benzene ring, and the alkyl group is increased so that it contains about 12 carbon atoms. Such an alkyl group may be named by the number of carbon atoms it contains. For twelve, this would be dodecyl. Thus a good detergent product of the above alkyl aryl sulfonate class would be dodecylbenzene sulfonate, whose formula may be represented approximately:



We have to say approximately since the product is always commercially manufactured as a mixture of products, just as commercial soap contains a mixture of fatty acids. This product resembles soap closer than the alkyl naphthalene compound mentioned above. In addition and unlike soap, its acid has considerable water solubility so that it is decomposed only in strong acid solution. Its calcium and magnesium salts are soluble to a concentration far above that normally found in the hardest water and unlike soap, they are not thrown out of solution. A little goes a long way.

The basic raw materials necessary for manufacture are kerosene or ethylene, both petroleum derived; benzene, either derived from petroleum or from the coal tar industry; sulphuric acid, and alkali. Due to the cheap and plentiful supply of raw materials and to the fine detergent powers of the product, about half of the total synthetic detergents presently manufactured in America belong to this class.

Many other type products are possible however. So many in fact that space will not permit even a brief listing. A good many types have not as yet been tried commercially, some types are too expensive to manufacture, in other cases the raw materials are not available. Although each type of product has in general the characteristics of detergency plus lime salt and acid stability, they differ considerably in the amount of water hardness they will withstand, in their detergent power, and in other characteristics which determine their end use. For example, the sulfated monoglyceride of coconut oil fatty acids as formulated below for lauric acid is not very alkali stable and is best used in industrial operations where this is not important. The cross check in the formula below shows where the molecule will split under adverse conditions.

$$CH_3\text{-}(CH_2)_{10}\text{—}COO/CH_2\text{-}CHOH\text{-}CH_2\text{-}OSO_3Na$$

When this unstable ester bond is replaced by nitrogen, a very excellent detergent is obtained. The following product known as Igepon T is expensive to manufacture and is used in America chiefly in industry, on special applications where cost is not critical, such as in the scouring of high priced piece goods in the textile industry. In pre-war Europe, where the economic situation was different, this material also found wide use in retail products.

$$C_{17}H_{33}CON(CH_3)CH_2\text{-}CH_2\text{-}SO_3Na$$

The sulfated alcohol from a fatty acid is alkali stable but not as acid stable as the alkyl aryl sulfonate. Its basic raw material cost is high but its detergent power is great. It finds a wide use in retail package products. Its formula, based on lauric acid is as follows

$$CH_3\text{-}(CH_2)_{10}\text{—}CH_2OSO_3Na$$

In all the products given above, the solubilizing agent was either the sulfonate $-SO_3Na$, or sulfate $-OSO_3Na$ group. Such products ionize like soap and are called anionic. The majority of present commercial synthetic detergents or "syndets" as they are sometimes called, fall into this class. Certain other means of solubilizing the hydrocarbon can be found, chiefly by the use of ethylene oxide available from petroleum sources. These products are not ionized. They are called non-ionic. For example, ethylene oxide may condense with an alcohol as follows:

$$RCH_2OH + CH_2\text{-}CH_2 \longrightarrow RCH_2O\text{-}CH_2\text{—}CH_2OH$$
$$\qquad\qquad\quad \diagdown\ \diagup \quad O$$

$$RCH_2\text{-}OCH_2CH_2OH + n(CH_2\text{-}CH_2) \longrightarrow RCH_2OCH_2(CH_2OCH_2)CH_2OH + RCH_2OCH_2(CH_2OCH_2)nCH_2OH$$
$$\qquad\qquad\qquad\qquad\quad \diagdown\ \diagup \quad O$$

Detergency occurs in the above type product when n is 12 to 15.

Ethylene oxide can be added to a wide variety of products containing the OH group, such as acids, phenols, hydroxy acids, etc. These products have low foam power except those derived from alkyl-aryl phenols and are widely used as liquid dishwashing compounds and in automatic washers. *(Continued on Page 36)*

Industrial Alcohol

• By **Donald M. Black, Ph.D.,** *(Massachusetts Institute of Technology)*
MONSANTO CHEMICAL COMPANY, MERRIMAC DIVISION, BOSTON, MASSACHUSETTS

Dr. Black writes an interesting account of the production of industrial alcohol. Under this head is included all alcohol produced at a minimum concentration of 80 per cent by volume, under very specific regulations, in plants rigorously defined separately from beverage alcohol plants.

He discusses the fermentation method employing blackstrap molasses, starches or cellulose, the synthesis of alcohol from ethylene, and its manufacture from hydrocarbon gases. Mention is made of the chief by-products of fermentation,—animal food, carbon dioxide and fusel oil.

●

Ethyl alcohol is probably the only chemical compound produced synthetically that has been known since the beginning of recorded history. The ancients were aware of its intoxicating effect without recognizing the active agent involved. These early people developed many methods for producing the material, all of which were based on the spontaneous fermentation of sugars. Throughout the ages ethyl alcohol has been known by a wide variety of names, such as "cologne spirits," "spirits of wine," "eau de vie," "aqua vitae" and "grain" alcohol.

Concentration of comparatively weak alcoholic solutions was not developed until the time of the Arabs and Romans, who evolved crude stills for the purpose. These people were the first to use what we today call industrial alcohol—that alcohol not employed as a beverage. The first uses were in the preparation of perfumes and cosmetics. Alcohol also found application in medicine. The civilizations that followed merely improved the distillation and purification processes. In fact, most authorities believe that the word "alcohol" is derived from the Arabic *al-koh'l*. *Koh'l* was the finely powdered black antimony sulfide widely used in the East for painting eyebrows. Use of the word eventually led first to its meaning any fine powder obtained by trituration or sublimation, and then to designate any essence or spirit. Finally the word was used in its modern sense to define the liquid itself. Paracelsus and Libavius used the term to denote a powder. The latter spoke of an "alcohol" formed from antimony.

The development of industrial applications of ethyl alcohol in the United States lagged in comparison to that of methyl alcohol because of the imposition of the high revenue tax occasioned by the Civil War. Despite excellent intentions on the part of Congress to exempt alcohol used in industrial applications from this tax, no simple means of differentiating beverage from industrial alcohol was available, as the practice of denaturing as we know it today was unknown at that time. Despite the development of a denaturing process by the British in 1853, it was not until 1906 that the addition of denaturing substances to industrial alcohol was authorized by the United States Government, with the subsequent elimination of the beverage tax upon a chemical commodity. During the era of Prohibition, production of concentrated alcohol for industrial and scientific uses continued.

All industrial alcohol must be at least 160 proof. A proof gallon represents one U. S. standard wine gallon (231 cu. in. volume) containing 50 per cent of alcohol by volume (42.5 per cent by wt.) The term "proof" is derived from an old chemical evaluation test used to determine alcoholic content; it is probably several centuries old. Proof alcohol was defined as that concentration of alcohol at which gun powder would ignite when saturated with the alcoholic liquid. As it so happens, practically all alcohol produced for chemical, physical, or manufacturing uses is originally recovered at concentrations of at least 95 per cent by volume, and in a relatively pure state. Regardless of source material, all alcohol produced at a minimum concentration of 80 per cent by volume is defined as industrial alcohol. It is today produced under very specific regulations, at plants designated as industrial alcohol plants, rigorously defined separately from beverage alcohol plants (registered distilleries). These latter differ sufficiently from industrial alcohol plants that their conversion to wartime production of the industrial product required an unsuspected amount of effort.

For the most part, two general methods are employed in the manufacture of ethyl alcohol. The most important of these is the technique of fermentation; the second is the reaction of ethylene with water under the influence of sulfuric acid.

Fermentation, in turn, can be based upon three general classes of raw materials: (1) saccaharine materials—those which contain sugar, such as molasses, sugar beets, sorghum, sugar cane, etc.; (2) starchy materials, such as cereal grains, potatoes, and the like; (3) cellulosic materials, such as wood and various agricultural residues. Included in this last class is the waste sulfite liquor obtained from paper-pulp mills, which contains the sugars derived from the hydrolysis of cellulose and hemicellulose.

A third means of ethyl alcohol manufacture that may become more important in the future is the Fischer-Tropsch process, or the "Synthine" or "Synthol" process, in which hydrocarbon gases are converted to a mixture of carbon monoxide and hydrogen, which is subsequently passed over a hydrogenation catalyst.

The process of fermentation requires the utilization of a biological organism that actually transforms the

organic material into alcohol. Substrates of the types containing sugar, those in the first group mentioned, are the simplest to use because they are directly fermentable. In the United States, the great bulk of the industrial alcohol produced is based upon molasses, which is obtained as a by-product in the preparation of sugar. Starchy materials, such as corn and potatoes, to name only those of commercial importance, are composed of comparatively complex carbodydrates which must first be converted to fermentable sugars. This preliminary step is carried out by any one of several means, such as the enzymatic action of malt, the direct use of molds, or treatment with mineral acids. Cellulosic materials, still more complex, are first converted directly to fermentable sugars by hydrolysis with mineral acids. Microorganisms other than yeast can exert fermentative action upon carbohydrates but the products obtained are not necessarily ethyl alcohol.

As pointed out above, most of the industrial alcohol produced in the United States has utilized blackstrap molasses as its raw material. This grade of molasses is the residue obtained after crystallized sugar has been removed from evaporated sugar cane juice. It contains 50 to 60 per cent of sugars in the form of mixtures of sucrose and invert sugar. Blackstrap molasses is beginning to find an expanding market as an additive to animal feedstuffs, and as this latter industry grows the cost of the molasses as a raw material for the production of alcohol will probably increase to the point where other raw materials or processes become more important factors in the preparation of industrial alcohol in the United States.

The biological organisms employed in these fermentation processes use the simple sugars as foods, and in the presence of oxygen oxidize them almost completely to water and carbon dioxide; under these conditions the organisms themselves multiply very rapidly. If oxygen is not present, the yeast still utilizes sugar as a food, but produces from it a variety of organic chemicals, chiefly ethyl alcohol. Thus, during the first few hours of fermentation, the yeast cells multiply to a concentration of about 150,000,000 cells per milliliter. At the end of about 24 hours, the fermenting mass boils vigorously as the carbon dioxide is liberated. When the concentration of ethyl alcohol in the fermenting batch reaches about 12 per cent, the yeast ceases its activity. In general practice, however, the concentration attained rarely exceeds nine per cent. In the case of molasses, the process is completed after about two days.

A great variety of starchy materials has been used or proposed in the manufacture of ethyl alcohol, ranging from potatoes and the cereal grains to the Jerusalem artichoke and several varieties of cactus. In the Untied States, only corn and grain sorghums among the cereals have found much application because of the relatively high prices commanded by wheat, rye, barley, and oats as human foodstuffs. Potatoes have been used to a minor extent in the United States, although continental Europe, especially Germany, has employed them extensively.

The stillage or "slops" resulting from the fermentation is a valuable by-product when cereal grains are used, since it is high in protein content and contains substantial quantities of vitamins. It commands a ready market, therefore, as an animal feed. The stillage obtained from molasses fermentation is a much poorer product in this respect.

Another by-product obtained during the distillation of the fermented mash is fusel oil, which is a mixture chiefly of the isomers of butyl and amyl alcohols. It is recovered at practically all industrial alcohol plants. The crude material is washed free of ethyl alcohol, and then either sold as is, or redistilled to meet definite specifications.

The third important by-product produced is carbon dioxide; roughly a ton is obtained for every ton of alcohol. It is used in the manufacture of "dry" ice, and also in the carbonization of soft drinks.

Simple distillation of an aqueous alcohol can never yield an alcohol stronger than the constant boiling mixture (the 95 per cent alcohol of commerce, containing 97.2 per cent by volume). Although this material is suitable for the great bulk of uses to which alcohol is put, an anhydrous material is often required. The water can be removed by chemical means, such as by the addition of hygroscopic materials such as quicklime, aluminum oxide, and the like. This method, of course, is not of commercial importance.

The commercial technique of removing water makes use of liquids, known as entrainers, that are miscible with alcohol but of limited miscibility with water. The operation is called azeotropic distillation. Thus, if benzene is added to a mixture of alcohol and water and the whole heated, a mixture of water, alcohol, and benzene will distil until all the water has been removed. The condensate separates readily into two layers, the upper chiefly benzene and the lower mostly water. The material remaining in the still is anhydrous alcohol.

Other solvents can be used, such as hexane, ethyl acetate, and the chlorinated hydrocarbons. A similar process employs glycerine, passing it downward through a still countercurrent to rising alcohol-water vapors.

The utilization of wood as a source of ethyl alcohol requires two steps: (1) the hydrolysis of the cellulose to sugar, and (2) fermentation of the sugars. The hydrolysis step is carried out usually by use of acid—either of low concentration at high temperatures, or of high concentration at low temperatures. Neither this process nor that of fermentation of waste liquors from the sulfite pulping process has proved economically feasible in the United States.

The first ethylene used as a raw material for alcohol was obtained from coke oven gas, but in this country petroleum gas is a more economical starting point. If the ethylene content in the gas is sufficiently high, the saturated hydrocarbons need not be removed. Most of the higher olefins, however, must be removed by

(Continued on Page 32)

An Island in the Tropics

● **By Alfred O. Gross, Ph.D.,** *(Harvard University)*
DEPARTMENT OF BIOLOGY, BOWDOIN COLLEGE, BRUNSWICK, MAINE

Since 1923, one of America's most interesting biological stations has been located on Barro Colorado, a 3600-acre, man-made island in Gatun Lake in the Canal Zone. This outpost has provided unusual and highly valuable opportunities for the study of the wildlife peculiar to the region, and the studies made there have added much to our knowledge of tropical animals and birds.

At Barro Colorado Dr. Gross's researches have pertained largely to birds. He writes so entertainingly of his experiences that many readers will be glad to visit the Station, if the opportunity ever comes.

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For a study of the bird life of a typical jungle in the Tropics there are few places that offer greater opportunities and facilities than that provided by the Barro Colorado Island Biological Station, located in the Canal Zone.

Barro Colorado is the largest island in Gatun Lake that was formed at the time the Chagres River was dammed in the construction of the Panama Canal. You may consider it as the top of a partially submerged mountain that is now an island 3.4 miles long and 3.1 miles wide, comprising about 3,609 acres. It has a very irregular coast which if projected into a straight line would approximate 25 miles in length. Practically its entire area is covered with a dense jungle of rain forest. The surface is hilly, some of the hills reaching an elevation of 537 feet above sea level, or about 450 feet above the average level of Gatun Lake. Running down between the hills and hidden by the luxuriant vegetation are rocky brooks which during the rainy season pour turbulent streams into the coves that reach in from the lake through avenues of jungle trees.

Naturalists are indebted to Dr. James Zetek, entomologist of the U. S. Department of Agriculture stationed at Ancon, Canal Zone, who first pointed out the possibilities of this island as a reservation to be preserved for all time for students of the Tropics. It was through Dr. Zetek's efforts, with the aid of fellow scientists, that the island was set aside on April 17, 1923, by the Governor of the Canal Zone, and that a laboratory and other buildings were constructed.

The group of buildings stands on the crest of a hill, and when you have climbed up the long series of steps to the main laboratory you gain a superb view of the lake and the forest-covered mountains of the mainland beyond. There, as you watch the ships of the world pass through the Canal and hear the airplanes overhead, you realize that even on remote Barro Colorado you have not escaped the mechanisms of civilization.

The laboratory is well equipped for the needs of the naturalist. There are running water, electricity, chemicals, microscopes, a dark room for photography, and even cases of skins to assist the beginner in identifying the many birds to be seen about the clearing, and others observed during excursions into the depths of the jungle. There are miles of well marked trails that have been cleared and are maintained in good condition so that all of the more interesting sections of the island are easily accessible to those who desire to study the wealth of wildlife.

The impression that visitors from the north generally receive on visiting Barro Colorado for the first time is that you are in a new world: new trees, new plants and strange forms of life so different from those you are accustomed to seeing in temperate regions. You hear weird calls and sounds which at first you cannot associate with any mammal, bird, or living creature with which you are familiar. As you travel for the first time the trails darkened by the dense luxuriant vegetation, it is with some misgiving and with awe of the unexpected. You may be startled by the guttural bellowing roars of a troop of black howler monkeys, which sound much more like that to be expected of pumas in deadly combat, rather than these comparatively harmless creatures of the tree tops. Again you may hear a crash through the intertwined vegetation ending with a resounding thud on the forest floor. What can it be? If you have the courage to investigate, you discover it is only a number of harmless coaties

FIGURE 1. The Toucan with its over-size beak of many colors is the most grotesque bird found on Barro Colorado Island. *(All photos by Dr. Alfred O. Gross.)*

FIGURE 2. An arboreal Ant Eater about to open a termite nest to feed on the ants. This animal has no teeth. After clawing open the nest, it thrusts out its saliva covered tongue. The ants cover the tongue. A delicious meal.

that have leaped or fallen from a tree where they have been feeding. They are much more frightened than you. A flock of noisy chattering parrots may suddenly dash across the trail and as quickly disappear in the dense foliage of a giant tree top. It is always the unexpected that makes your experience so thrilling and exciting.

As you saunter along the trail you are critically watched by the eyes of many creatures that are so quiet and so well concealed that you do not see them. To obtain the most out of a walk along the trails it is well to go alone and to use the technique of the animals and birds of remaining quiet and concealed. One by one the creatures will start their normal routine seemingly unaware of your presence.

On one occasion when I was standing beneath the overhanging leaves of a palm, curious monotonous frog-like *kree, kree, kree* calls were heard. Scanning the vegetation in the direction of the calls I was amazed to discover they were being uttered by a large bird not more than 30 feet away, for up to that time its presence had entirely escaped my notice. The bird had an enormous multicolored beak, bright lemon throat, and a breast bordered by a band of deep red. It had a conspicuous white rump which stood out in strong contrast to the glossy black upperparts. It was the short-keeled toucan, one of the most grotesque and exotic looking birds to be seen in the Tropics. The beak of many colors, shaped like a huge banana, was altogether out of proportion to the rest of the bird, a feature which also impresses the natives as reflected in the names *Curre de pico grande* or *Pico feo*. This bill, a striking adaptation to its peculiar feeding habits, is an example of the many evolutionary developments to be found among birds, especially those of the Tropics. As the bird repeated its call it threw up its bill in a vertical position. With each succeeding *kree* the wings were slightly dropped as it went through its peculiar mechanical performance. It was a part of the courtship executed for the benefit of his mate. The gorgeously colored toucan, perched among the deep shadows and highlights, was just as difficult to see as a dull, protectively colored bird would be in an open environment. You may see a flock of highly colored parrots alight in a tree of the dense forest and disappear as if by magic so perfectly do they blend with the variegated lighting of their surroundings. It is only with patience and watchful waiting that you will succeed in seeing the authors of many of the notes you hear.

One of the most beautiful scenes of tropical bird life I have ever seen was on an early morning in October when I was concealed in a blind along one of the trails. Seven massena and five graceful trogons were dexterously balancing and suspending themselves from the long-drooping vines hanging down from a giant sand box tree. The sun filtering through the jungle roof illuminated the whole scene in such a way that the magnificent iridescent colors of the birds, the foliage, and the brilliant red fruits on which they were feeding, showed up at their best. Sometimes there was keen competition for a certain branch with an abundance of fruit. This usually resulted in a tussle involving a vigorous flapping of wings that dislodged many fruits and sent them raining down on the forest floor.

Because the brightly colored species of birds are the ones most likely to attract attention, the brilliant colors of tropical birds have frequently been overemphasized. There are just as many birds with a modest sombre coloration. This is particularly true of terrestrial species that inhabit the undergrowth or the forest floor, among which are the so called antbirds. As the name suggests these birds feed primarily on ants which are excessively abundant and a predominant form of life throughout the Tropics.

If you follow these ground inhabiting birds through the undergrowth they may unwittingly lead you to their nesting site. This is how I discovered the nest of a Schlater's antbird, a small, inconspicuous, brown colored bird. The nest, made of coarse stems and roots

(Continued on Page 35)

FIGURE 3. Base of a giant Sand Box Tree. The relative size of tree and persons is apparent.

Pius XII, Science, and Scientists

● **By Sister M. Ignatia, I.H.M., M.S.,** *(The Catholic University)*
DEPARTMENT OF CHEMISTRY, MARYGROVE COLLEGE, DETROIT, MICHIGAN

Some of our readers may be unaware of the live interest of Pope Pius XII in the physical sciences, and of his attitude toward scientists and scientific research.

In this paper have been gathered together a number of pronouncements made on various occasions that give a clear idea of his regard for workers in science and their accomplishments.

"By your research, your unveiling of the secrets of nature, and your teaching of men to direct the forces of nature toward their own welfare, you preach at the same time in the language of figures, formulas and of discoveries, the unspeakable harmony of an all-wise God."

●

Pius XII, the gracious and beloved reigning Pontiff, is world renowned as a saintly priest, a scholar, and a statesman. Few Americans realize, however, the great interest of the Holy Father in the physical sciences; still fewer know of his efforts to make men understand the harmony that exists between faith and true science.

When, as Cardinal Pacelli, he visited the United States in 1936, he spoke at the Catholic University of America in Washington, D. C. The topic of his address was "Religion and Science." During the years of his pontificate, he has spoken frequently on similar or allied themes, but with no noticeable repetition. He writes all of his addresses and documents himself, and a study of even a few of the more than thirteen hundred published to date reveals the wealth of his personal knowledge and his mastery of words. Some of the addresses of the Holy Father on scientific topics have been delivered at sessions of the Pontifical Academy of Sciences. Others have been given to congresses held in Rome of such groups as the Italian Society for the Advancement of Science, one to the delegates of the International Congress on Mathematical Sciences, and many to visiting groups of professors and university students. A notable discourse on science and faith was delivered by Pius XII at the time of the beatification of Contardo Ferrini.

We must include among the documents of Pius XII on scientific subjects, some of his letters, such as the one he wrote to the Master General of the Dominicans on the feast of Saint Thomas Aquinas in 1942, shortly after Saint Albert the Great was declared and constituted forever by the Holy Father "the Patron before God of Students of the Natural Sciences."

It is interesting to note that when the Pontifical Academy of Sciences was reorganized by Pius XI in 1936, it was Pius XII, then the Papal Secretary of State, who delivered the opening address. Pope Pius XI had planned to preside personally at the opening ceremony of the renewed Academy and to give audience to the seventy members he had himself carefully chosen. He had looked forward eagerly to the event, but the condition of his health on that day was such that he was unable to attend the session. According to Cardinal Pacelli's opening address,

> It was the dearest wish of the Supreme Pontiff to be able to inaugurate himself this scientific senate; for its mission appeared to him to come in all its effulgence out of the same divine source whence there pour out and descend to man the potent streams of the natural and rational sciences and the great river of revealed wisdom.[1]

In the course of the address, the Cardinal spoke on the relationship of science and faith:

> In truth, there are many to whom science and faith spell an almost irreconcilable contrast. It is not so and it cannot be so for the Holy Father nor for those who consider that science is the quest for truth as it is to be found in the natural relation of creation, and that faith is the homage of created intellect to the truth directly revealed by the Creator. Thus, it is evident that this homage of created intellect will never be more worthy of the Creator than when it is illuminated by the splendors of science.[2]

The present Pontifical Academy of Sciences is a restoration of the one founded in 1603 in Rome by Prince Federigo Cesi and called the Accademia dei Lincei, the Academy of the Lynxes. The chief interest of the group was in physical, mathematical, and philosophical studies. In the words of Prince Cesi, the object of the institute was "not only the acquisition of the knowledge of things and of wisdom by the practice of a righteous and religious life, but also the instruction of men by word of mouth and by writing."[3] Prince Cesi meant the Academy "to lie within the Aristotelian frame of thought."[4] Since it was alive to the times, however, it broke with the Aristotelian tradition about 1609, "willingly gave hospitality to Galileo . . ." and "printed his dissertation on the sunspots."[5] About the year 1609, one of the members of the Academy, possibly Prince Cesi himself, coined the word *telescope* from the Greek roots *tele*, afar off, and *skopos*, to view or to see.

For almost fifty years the Academy was held in the highest prestige, but after the death of Prince Cesi it died out. Pope Benedict XIV reinstated it as the "Accademia dei Nuovi Lincei." It was active at the beginning of the nineteenth century, but died out again during the pontificate of Gregory XVI.[6] In 1847, Pius IX reinstated it as the "Pontificia Accademia dei Nuovi Lincei," and its intellectual leadership lasted until the loss of the temporal power of the Popes in 1870. Leo

XIII gave the Academy another constitution, and finally, Pius XI reformed and reorganized it in 1936 on an international scale such as it had never known before.

Membership in the Academy is honorary and for life. Representatives of fifteen nations and of all branches of science, Catholics, Protestants, and Jews, clerics and laity, were found among the seventy noted scientists chosen as members. Six of the original seventy selected in 1936 by Pius XI were Americans. George D. Birkhoff, Professor of Mathematics at Harvard University; Alexis Carrel, Professor of Biology at the Rockefeller Institute; Robert A. Millikan, Director of the Physics Laboratory at California Institute of Technology; Thomas H. Morgan, Head of the Department of Biology at the same institute; George S. Sperti, Director of the Institutum Divi Thomae of the Catholic Athenaeum of Cincinnati, Ohio; and Hugh Stott Taylor, Professor of Chemistry now Dean of the Graduate School, at Princeton University.[7] Peter Debye, Chairman of the Department of Chemistry at Cornell University since 1940, was chosen as a member of the Pontifical Academy of Sciences in 1936, but was classified as German until 1947. Starting with the issue of *Annuario Pontificio* for 1948, Germania was replaced by U.S.A. after Debye's name.

By 1946, Doctors Birkhoff, Carrel, and Morgan had died, and on May 29, 1948, *L'Osservatore Romano* announced that Edward Adelbert Doisy, Professor of Biochemistry at Saint Louis University School of Medicine, and Herbert Sidney Langfeld, Director of the Psychological Laboratory of Princeton University, were among the six new members chosen by the Pontifical Academy of Sciences.[8] A glance at the list of the sixty-two living members of the Academy in *Annuario Pontificio* for 1951 reveals such names as Appleton, Bohr, Fleming, Lemaitre, Rasetti, Schrödinger, and Whittaker. Following the regular members are listed the names of the five supernumerary members, including Luigi Gatterer, S.J., the prefect of the Astrophysical Laboratory of the Vatican Observatory, and Giovanni Stein, S.J., director of the same observatory, which, incidentally is considered by astronomers as one of the best in Europe.

Before his coronation as Pope Pius XII in March of 1939, Cardinal Pacelli, as Papal Secretary of State, was listed in *Annuario Pontificio* as the first of the Academy's honorary members. On December 3, 1939, at the inauguration of the fourth year of the Academy, he formally addressed the assembled members and reminded them that once before in that same room they had heard his words bringing them the message of his Predecessor. After a glowing tribute to Pius XI, the present Holy Father spoke of truth,

> . . . which rising from the abyss of earth and the sea and descending from the heights of the heavens, assembles your investigating genius and your scholarly voice to sing the hymn of human reason dedicated to the traces of the Creator left in the universe, when He made the skies and the earth and all their ornaments.[9]

> Truth . . . lives bound up in everything we see, hear, smell, taste, touch and feel, in thousands of forms, . . . and often threatens us with the terror of strength stronger than our instruments, . . . Such is the vigor, the appeal, the beauty, and the intangible life of truth which is set free by the aspects and by the investigation of the immense reality that surrounds us.[10]

Later on in the address, the Holy Father spoke of man

> . . . whose spirit is the image of the Eternal One, a spirit in which each one of you who knows its admirable prison of muscle, bone, nerves, veins, blood, and fibre must sense a nobility and greatness, . . .[11]

and of man's search for God.

> By the stairway of the universe man climbs up to God: the astronomer arriving at the sky, the footstool of the throne of God, cannot be incredulous to the voice of the firmament: there behind the suns and astral nebulae, the thought of man crosses over followed by love and adoration and sails toward a Sun that illuminates and warms not the clay of man, but the spirit that gives life.[12]

The Holy Father also urged his listeners toward further research:

> To the joy of knowledge, do you, chosen men of talent, unite the art of research for truth; and in the retirement of your studies and laboratories, be not the same person who entered, but become rich in that thinking which is the conquest of the enigma, (i.e., the truths of the universe) in order to increase the wonderful patrimony of science.[13]

He stressed the fact that "the Church acknowledges the just liberty of method and of research, a liberty upon which our immortal Predecessor, Pius XI, founded this Academy . . ."[14] To emphasize the Church's recognition of the liberty of science as well as her responsibility in guarding against error, the Supreme Pontiff quoted the Vatican Council:

> Nor indeed does she [the Church] forbid that any disciplines of this kind in their own orbit use their proper principles and powerful methods, but recognizing this just liberty she diligently is on guard, lest by opposing divine operation they beget errors, or by deserting those things which are of faith, they hinder and confound their proper ends.[15]

Is not the recent Encyclical Letter of Pius XII, *Humani Generis*, an example of such watchfulness on the part of the Church? In that Encyclical, we read:

> It remains for Us now to speak about those questions which, although they pertain to the positive sciences, are nevertheless more or less connected with the truths of the Christian faith. In fact, not a few insistently demand that the Catholic religion take these sciences into account as much as possible. This certainly would be praiseworthy in the case of clearly proved facts; but caution must be used when there is rather question of hypotheses, having some sort of scientific foundation, in which the doctrine contained in Sacred Scripture or in Tradition is involved. If such conjectural opinions are directly or indirectly opposed to the doctrine revealed by God, then the demand that they be recognized can in no way be admitted.
>
> For these reasons the Teaching Authority of the Church does not forbid that, in conformity with the

present state of human sciences and sacred theology, research and discussions, on the part of men experienced in both fields, take place with regard to the doctrine of evolution, in as far as it inquires into the origin of the human body as coming from pre-existent and living matter—for the Catholic faith obliges us to hold that souls are immediately created by God. However this must be done in such a way that the reasons for both opinions, that is, those favorable and those unfavorable to evolution, be weighed and judged with the necessary seriousness, moderation and measure, and provided that all are prepared to submit to the judgment of the Church, to whom Christ has given the mission of interpreting authentically the Sacred Scriptures and of defending the dogmas of faith.[16]

On February 21, 1943, Pius XII delivered another significant allocution to the Pontifical Academy of Sciences. In it he spoke of the importance of the concept of physical law:

The empirical researches of the past few decades, following closely upon the study and work of the last century, can boast of discoveries and inventions of the first importance—to mention only the artificial transformations of the atomic nucleus, the splitting of the atom, and the marvels of small-scale investigation revealed by the electronic microscope. Scientific progress has led to the knowledge of new laws in natural phenomena and thrown new light upon the essence and value of physical laws. There is perhaps no problem which so much absorbs the attention of the most eminent among physicists, chemists, astronomers, biologists, and physiologists—and we may say also of modern students of natural philosophy—as that of the laws which regulate the order and action of the material substances and phenomena operating on our planet and in the universe.[17]

The Holy Father then traced the changes during the past one hundred years of the concept of physical law, summarizing with the statement that

. . . while the assertion of natural laws subject to no exception whatever has been so much shaken by the progress of exact science, that people are now almost falling into the opposite excess of talking only of laws of average, statistical norms, and laws of probability. This mode of thought is legitimate to the extent that many of the laws of the sense-world and macrocosm manifest a statistical character—because they do not express the behaviour of every single being but the average process of an immense number of similar beings—and therefore show themselves amenable to the calculus of probabilities. But to see in the world nothing but statistical laws is an error of our age; while to assert that the old rigorously dynamic conception of natural law can be completely abandoned and has become meaningless, is to forswear the nature of the human mind, . . .[18]

Elsewhere in his allocution, the Holy Father says of statistical laws:

In the closely concatenated and organized system to which science has reduced the macrocosm there are doubtless many statistical laws; but these, when we consider the number of elements involved (atoms, molecules, electrons, photons, etc.), do not fall notably short of strictly dynamic laws in certainty and exactness. In any case, they are founded and, as it were, anchored in rigorously dynamic laws of the microcosm, although our particular knowledge of microcosmic laws is as yet almost non-existent, in spite of the strenuous efforts made in recent investigations with a view to understanding the mysterious activity of the inner recesses of the atom. Gradually it will be possible to lift these veils; the apparently non-causal character of microcosmic phenomena will then disappear: a new and marvelous kingdom of order, a rule of order even in the minutest particles, will be discovered.[19]

The remainder of this allocution is concerned with the objective reality of knowledge and the refutation of phenomenalism.

If what you perceive and know were only the images of your sensations, it would follow that all natural sciences—from the stars to the atom, from the sun to the electric light, from the minerals to the cedars of Lebanon, from microbes to man and the medicines that cure his diseases—would not be dealing with things outside your mind, but only with the intelligible images which you contemplate in your mind even when you are dreaming. The science which exalts a Copernicus and a Galileo, a Kepler and a Newton, a Volta and a Marconi, and other famous and deserving investigators of the external physical world that surrounds us—this science would be nothing but a beautiful day-dream, a fanciful story of the physicists; the appearance would take the place of the reality and truth of things; and to assert or to deny one and the same thing would be equally true. No; science does not deal with dreams or with the images of things, it deals with things themselves, through the images which we draw from them.[20]

The address delivered by the Holy Father to the Pontifical Academy of Sciences on November 22, 1951, is probably the most significant of all. Since it received wide publicity, however, only a brief quotation will be given here. In his introduction, Pius XII said to the members of the Academy,

. . . by your research, your unveiling of the secrets of nature, and your teaching of men to direct the forces of nature toward their own welfare, you preach at the same time, in the language of figures, formulas and of discoveries, the unspeakable harmony of the work of an all-wise God.

In fact, according to the measure of its progress, and contrary to affirmations advanced in the past, true science discovers God in an ever-increasing degree—as though God were waiting behind every door opened by science.[21]

On December 16, 1941, at the request of Agostino Gemelli, O.F.M., president of the Pontifical Academy of Sciences and also president of the Catholic University of Milan, Italy, Pius XII issued an Apostolic Letter declaring Saint Albert the Great "forever the Patron before God of Students of the Natural Sciences."[22] This famous Dominican, born during the last decade of the twelfth century, has long been known as a teacher of Saint Thomas Aquinas, but in his Apostolic Letter the Holy Father stressed some points that are not so well known.

Had the principles established by the great Bishop of Ratisbonne on the necessity of experimentation and keen observation, on the importance of induction to find the truths of nature, been rightly understood and effectively exploited in his day, the marvellous advances made in the sciences, the proud boast of our own and the generations of the recent past, might have been attained centuries

ago and have been fixed upon firm foundations to the best advantages of human society.[23]

Shortly after he declared Saint Albert the Great patron of students of the natural sciences, Pius XII wrote a letter to the Most Reverend Martin Gillet, Master General of the Order of Friar Preachers, in which he showed the interest of the Papacy in scholars:

> Because those who devote their lives to sacred or profane science have much influence in guiding and ordering the lives of others, and because sound doctrine begets sound morals in both private and public life, the Roman Pontiffs have always had the greatest interest in those learned men who give themselves to the pursuit of the nobler arts and sciences, and thus light up the way for the feet of humanity.[24]

After referring to Saint Thomas Aquinas, the patron of all Catholic schools, Pius XII praised Saint Albert the Great who

> . . . while he speculated on the deep secrets of nature to the uttermost reach of his mind and with keenest pleasure of soul, . . . was carried away to a wider and higher plane of intelligence; borne aloft to the supreme Artificer and Ruler of all things, he bowed down before Him in humble adoration.
>
> It is especially for this reason, beloved son, that we decided to select and constitute him patron of scientists: in order that the students of the natural science, bearing in mind that he had been given to them as their guide, might follow his footsteps and not cling too tightly to the investigation of the fragile things of this life, nor forget that their souls are meant for immortality, but use created things as rungs in a ladder that will elevate them to understand heavenly things and take supreme delight in them. May they discern the presence of God in all the forces of nature, and, in meditation and veneration, admire the incorruptible rays of His splendor . . . and may they adore and revere His creative and eternal wisdom, not only in the harmonious and wondrous march of the stars which obey the supreme Will throughout the boundless spaces of the heavens, but also in the hiding-places of that tiny world which is known only to the eye of the microscope.[25]

In 1949, a Cancer Study Week sponsored by the Pontifical Academy of Sciences was the occasion of another address by Pius XII. In it he contrasted the imprudent announcements of sensational cancer cures with the quiet work and modest pronouncements of true scientists:

> How much more modest and, therefore, how much higher and surer is your ambition, gentlemen! In reality, a great many hypotheses have been brought forth and many theories have been timidly built up and discreetly proposed. They are certainly not to be belittled because, even if they are not verified, they open the door to new and more effective research. They mark, therefore, some progress, doubtless valuable, but of necessity, very slow.[26]

The day after Pius XII issued the Apostolic Letter[27] announcing the beatification of Contardo Ferrini, an Italian university professor, he spoke at length to a group of pilgrims who had come to Rome for the beatification ceremonies. The subject of the allocution was the relationship between science in the broad sense, i.e., learning, and faith,

> For Learning and Faith distinguished our Contardo—that learning which is no obstacle to Faith, but which he made into a rung to climb on it nearer to God and to the faith of his fathers; embracing in his life as in a synthesis both human and religious knowledge, to rise finally to another supreme knowledge: the knowledge of the Love of Christ.[28]

The scholarly research of Contardo was in the sources and the history of Roman law and in the principles of jurisprudence rather than in the physical sciences, but he is held up by our Holy Father as a model for all scholars, for

> In him [Contardo Ferrini] all was transparent clarity, secure calmness, serene joyfulness of the spirit, sincere devotion to, and unchanging love of truth. Sober and reserved as he was in his outward appearance, his work radiated the inner, restrained flame of a man who has dedicated his life to the quest for truth and who behind the noble countenance of all earthly science is always seeking the eternal Truth of God.[29]

Contardo lived from 1859 to 1902[30] and achieved sanctity during a period characterized by so much in the outer world and in the very activity of learned men themselves that may lead away from God. Toward the end of his allocution, Pius XII declared:

> . . . Ferrini was a saint of his times, of the century of frenzied activity; the century during which the mind and the hand of man have reached out to conquer by technology and science the active energies of the entire physical universe . . .
>
> . . . He is the man of modern reality, but also the saint of the present hour: the mystic of the union with God, in whom he was immersed, and at the same time, so to speak, the mystic of fact and action—of that assiduous industry which is not construed, through a misconception of the divine order, as an end in itself, nor enhanced to be a kind of substituute for religion; . . .[31]

There are many other documents of Pius XII that are of interest to teachers and students of the physical sciences, documents, for example, in which he writes of truth, the intellectual life, the joy of knowing and teaching, the task of university men. Many of them have not yet been translated in their entirety into English, but they may be located by means of the recently published *Guide to the Documents of Pius XII*.[32]

We have a Pope who is not only a great spiritual father, but also an intellectual father, who is trying to inspire us with a desire to serve God by the dedication of our lives to the service of truth, truth known from nature, and truth directly revealed by God. "These are surely the things, distinguished scholars, that ought to encourage you to pursue your work with the confidence that is not undertaken in vain."[33] ●

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Autumn Adventures

● By W. Drew Chick, Jr.
CHIEF, NATURALIST DIVISION, NATIONAL CAPITAL PARKS, WASHINGTON, D. C.

This helpful paper is designed especially for science teachers in the early grades, a field of education not too well covered journalistically. It reflects experience, good sense, and good teaching. Don't wait until Autumn to read it!

The writer points out that nature study can be carried on without visiting remote places. He shows how the teacher may summarize in the classroom the results of a nature walk, and how the pupils' observations may be made the basis of useful projects in other departments.

●

Elementary school science may be an ever so much richer experience for the child and the teacher when trips to nearby parks, wild areas, or even empty lots in the neighborhood are scheduled regularly. This discussion on how some living things prepare for winter is just a seasonal example of what may be learned by first hand observation.

For many years we naturalists of National Capital Parks, Washington, D. C., have conducted classes on field trips upon invitation from school teachers. At the outset, the children have been encouraged to use their eyes to discover things of interest to them. It is remarkable how keenness of sight and perception improve with a little guidance from the naturalist.

Across the street from Jackson Elementary School is Montrose Park, a typical manicured city park with close clipped lawns, tall trees, shrubs, hedges, and flower beds, and some play equipment. To the unobservant, such a place would appear far from productive for a nature walk, but third grade children soon found it otherwise on a brisk November morning.

Each of us bundled up in our winter woolens were in sharp contrast to the bareness of the deciduous trees. We noted that the oak, maple, hickory, ash, and many others had dropped their leaves, but that the magnolia, holly, pine, hemlock, and fir retained their green coats.

"Why?" the children chorused.

"Let's find out," I suggested.

Each child was asked to pick up a brown oak leaf which had fallen from a nearby tree.

"Notice how thin this leaf is," I said. "Now, let's compare it with the leaves on the trees which are still green."

We walked to a magnolia tree nearby. Each child fingered a leaf and noted how thick and stiff it was compared to the oak leaf held in their other hand. They noticed also that the upper surface was shiny, like a freshly polished shoe. The thickness of the leaf and its wax coat protect it from drying out, and the sap ("blood") is not affected by cold weather. In deciduous trees, sap does not flow until springtime comes.

The American holly tree with its brilliant red berries and bright green leaves reminded us of the holiday season soon to come.

"It's a real live Christmas tree covered with gifts," Mary Jane observed.

"Gifts for what?" asked John.

"The berries are food for the birds," Mary Jane replied. "Look, a blue jay is eating them right now!"

"What other birds spend the winter with us?" I asked.

Various children replied in quick succession: "Cardinal, bluebird, chickadee, nuthatch, starling, flicker, sparrow, mockingbird, woodpecker."

"But what has happened to the hummingbird, the swift, flycatchers, warblers, and swallows?" I persued the thought farther.

These and many other birds have migrated south for the winter. Nectar from flowers, and insects cannot be found here any longer now that cold weather has come.

"DISCOVERIES OUTDOORS in winter are just as rewarding." The teacher and her class are assembled with the park naturalist at the start of a series of adventures with snow on the ground.

These birds must go where they can find the kinds of food on which they live.

"There's a squirrel running along that branch. Did you see him jump to the other tree? He disappeared into a hole. Is that his house?"

"Yes," I replied. "In the winter squirrels make use of holes in the tree trunks where dead limbs have fallen off and left cavities (like those the dentist fills in your teeth) in the trunk of the tree. Squirrels are active all winter long here in Montrose Park except on the coldest days. Then they stay in those holes all curled up like a little bundle of fur and sleep until the air warms up again. They live on acorns, hickory nuts, bark, and scraps of food that people leave behind. Of course, their fur coat grew thicker and heavier as autumn days became colder."

"Mr. Chick, how did this bump get here?" called Ronald excitedly.

"Let's all go and see what Ronald has found."

"Oh, that's nothing to do with nature," Jimmy laughed, "that's just a gob of molasses chip candy!"

"Aw, go on," someone else chimed in, "nobody would leave their candy sticking to a bush like that and besides it would have melted away in last night's rain. What is it, Mr. Chick?"

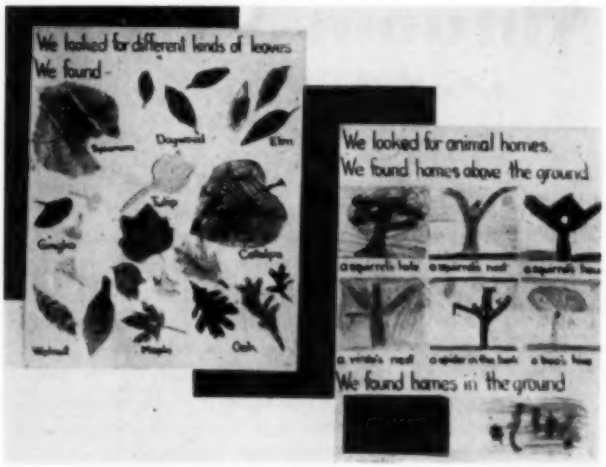
"Why, you really have sharp eyes, Ronald. That's a wonderful discovery you have made. This, children, is the egg mass of the praying mantid and there are hundreds of eggs here. Late next spring, if all goes well, hundreds of tiny mantids less than a half-inch in length will hatch out of this mass. Each will search for other insects to eat and as they grow larger, wings will develop so they can fly from place to place. By next September, they will be six inches or more in length and will have great big appetites. At mating time, the female mantid eats the smaller male. Later on, she produces a frothy mass containing the eggs and it hardens into the bump that Ronald found here. A few days later, the female mantid dies. Boys and girls should always leave these egg masses where they find them, and should never kill the mantids, for they help everyone by eating other insects which are harmful to man or his crops. These egg masses also may help other creatures to live through the winter. I have seen downy woodpeckers feeding on them."

"Ouch!" Susan exclaimed, "something stung me on my leg."

Everyone stopped, and sure enough, caught in Susan's bright red socks were three, dark-colored, sharp-pointed things about an inch long.

"They don't wiggle, so they can't be animals," Susan said as she took courage to pull them out and examine them closely. "These look like seeds from some plant."

"Yes, they are," the naturalist added. "They are from a plant called Spanish needles *(Bidens)* and a few weeks ago they had bright yellow flowers which all of you admired. How they got into Montrose Park I'm not sure, but since they have 'hitch-hiker' seeds, maybe last year someone walked up here from Rock Creek Park, pulled the seeds from their clothing, dropped them, and they took root and grew. Let's see if we can find the plant they came from."



SOME OF THE classroom follow-up of a trip in early autumn when emphasis centered on kinds of trees, their leaves, fall colors, animal homes

After diligent search a clump of the plants was found that had escaped the blades of the mowing machine all summer because they were growing close to a rock. The plants had turned brown, but before doing so had blossomed and produced seeds from which new plants will grow next year.

In just a few minutes time in Montrose Park, the children, their teacher, and I had had many outdoor experiences which were summarized later by the teacher in the classroom. Her summary may have been like this: Some trees are green all the year around because their leaves and the sap are conditioned for cold weather; other trees lose their leaves before cold weather comes; some birds stay with us in winter because they can find the proper food to eat, others migrate to the south; squirrels remain active except on the coldest days in Washington, but they have heavy fur coats to keep them warm; the praying mantid dies before winter cold sets in, but first lays a mass of eggs that hatch out in the spring; trees keep growing year after year, but other plants like Spanish needles live one year and die leaving seeds to grow new plants next year.

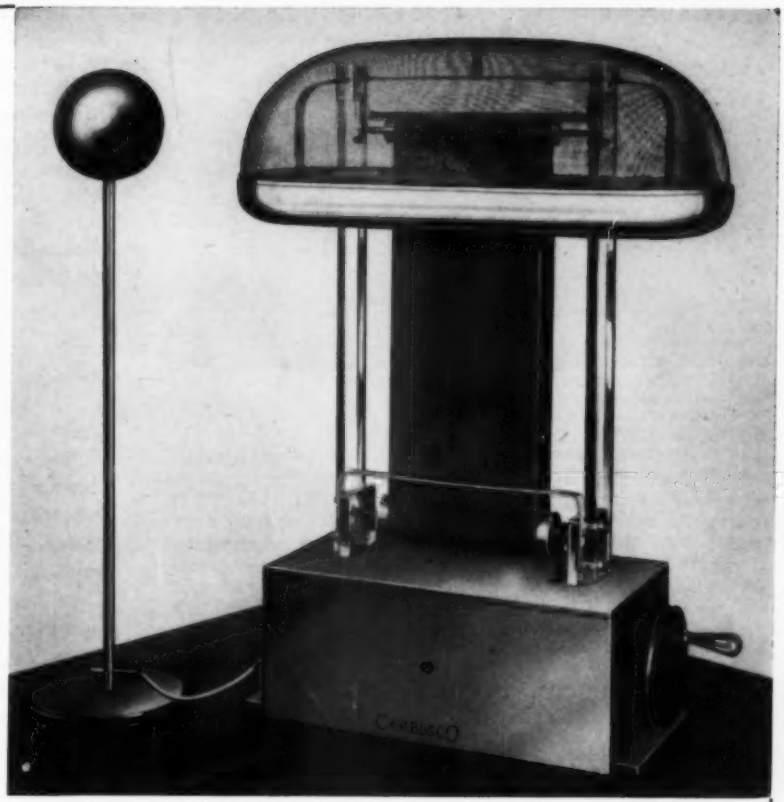
Each one of these discoveries could be the basis for an original English composition, or the subject for library research. They might stimulate poetic ability, art, or provide background for enjoying a musical number. Most certainly each child became more keenly aware of his surroundings with the opportunities thus afforded to use his senses for autumn adventures. Discoveries outdoors in winter are just as rewarding. Try it! ●

FIRSTURN* ELECTROSTATIC GENERATOR

Of Van de Graaff Design★

Delivers Discharge of 200,000 Volts▲

Self-starting and self-exciting. Needs no "priming." •Requires no auxiliary power supply. •Involves not the slighest hazard to operator or observer.



SPECIFICATIONS

Like its larger prototypes, the Firsturn Electrostatic Generator consists, essentially, of an endless, charge-conveying belt, which, as the crank is turned, moves into and out of a hollow metal terminal. Thus is the Van de Graaff principle reduced to its simplest, most comprehensible terms.

The belt travels upward from a solid metal roller to an adjustable, insulating roller which is supported on massive pillars of *anti-static* plexiglass. Those pillars likewise support the discharge terminal which, for visibility, is fashioned from woven bronze gauze. At the top of the terminal, provision is made for leading the charge to a Leyden jar, or to any of the accessories commonly employed with static machines.

Although the Firsturn Generator is primarily designed for hand operation, the drive wheel is grooved, to serve as a pulley when a motor drive is desired.

A mounted discharge ball, of heavy brass, is furnished with each Firsturn Generator. Jacks are provided for connecting that ball to the generator base, and for grounding the generator. Operating instructions are included.

Principal dimensions are as follows: Height, overall, 21-3/4 in. Width of terminal, 16 in. Width of belt, 5 in. Size of base, 6 x 13-1/2 in. Diameter of discharge ball, 3-1/2 in.

NOTES

•So named because a spark is produced at the first turn of the crank.

★Licensed under United States Patent No. 1,991,236, as issued to Robert J. Van de Graaff.

▲A conservative rating, based on many trials under average operating conditions. Under ideal conditions, a potential difference of 300,000 volts has been achieved.

At the first turn of the crank, this modern Electrostatic Generator emits a crashing spark, whether the day is dry or humid! For that reason alone, it will be welcomed by every physics teacher who has ever apologized for the temperamental performance of an old fashioned "static machine."

NO FRAGILE PARTS. The Firsturn Generator is constructed entirely of aluminum, brass, plexiglass, rubber, steel and wood. There are no Leyden jars; in fact, no condensers of any kind. There are no plates to warp or break; no shunts, brushes or collectors to adjust; no segments or button disks to re-stick!

NO "TRANSFER BODIES." In conventional influence machines, whether of Holtz or of Wimshurst type, charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies include: brushes, rods, button-disks, and foil or metal segments, each of which, inevitably, permits leakage of the very charge it is designed to carry, and thereby sharply limits the maximum voltage. In the Firsturn Generator (but in no other self-exciting electrostatic machine) electrical charges are established *directly* upon the discharge terminal.

AT THE LECTURE TABLE, the Firsturn Generator enables you not only to perform the classical experiments in static electricity, but also to demonstrate the *modern method* of building up tremendously high voltages for atomic fission, for nuclear research, and for radiation therapy.

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Pius XII and Science

(Continued from Page 26)

5. *Ibid.*
6. *Ibid.*
7. "Elenco Degli Accademici," *Acta Apostolicae Sedis*, 28 (October 28, 1936), 447-451.
8. *L'Osservatore Romano*, 88 (May 30, 1948), 2.
9. Pius XII, Address, *Al gradimento*, December 3, 1939, *Discorsi e radiomessaggi di Sua Santita*, Milano, Societa editrice "Vita e Pensiero," I, 400. Translation quoted is by Sister Marie Liguori, I.H.M.
10. *Ibid.*, p. 401.
11. *Ibid.*, p. 402.
12. *Ibid.*, p. 403.
13. *Ibid.*
14. *Ibid.*, p. 406.
15. *Ibid.*, pp. 406-407.
16. Pius XII, Encyclical, *Humani Generis*, August 12, 1950, (N.C.W.C. edition), pp. 16-17.
17. Pius XII, Allocution, *In questa solenne adunanza*, February 21, 1943, *Clergy Review*, 23 (November, 1943), 519.
18. *Ibid.*, p. 520.
19. *Ibid.*, p. 521.
20. *Ibid.*, p. 523.
21. *L'Osservatore Romano*, 91 (November 23, 1951), 1. Translation from *The New York Times*, November 23, 1951, 6 C.
22. Pius XII, Apostolic letter, *Ad Deum per rerum naturae*, December 16, 1941, *New Scholasticism*, 17 (January, 1943), 89.
23. *Ibid.*, p. 88.
24. Pius XII, Letter, *Quandoquidem qui sacris*, March 7, 1942, *New Scholasticism*, 17 (January, 1943), 89.
25. *Ibid.*, pp. 91-92.
26. Pius XII, Address, *Si la surcharge*, June 8, 1949, *Catholic Mind*, 47 (November, 1949), 700-701.
27. Pius XII, Apostolic letter, *Providentissimum Deum*, April 13, 1947, *Acta Apostolicae Sedis*, 40 (January 28, 1948), 18-26.
28. Pius XII, Allocution, *Con singolare gradimento*, April 14, 1947, *Seminar*, 5 (1947), Annual Extraordinary Issue of *The Jurist*, 1-2.
29. *Ibid.*, pp. 10-11.
30. Donald Attwater, *The Lives of the Saints*, (Butler), First Supplementary Volume, London: Burns, Oates & Washbourne, 1949, p. 152.
31. Pius XII, Allocution, *Con singolare gradimento*, loc. cit., pp. 12-13.
32. Sister M. Claudia, *Guide to the Documents of Pius XII*, Westminister, Maryland: The Newman Press, 1951.
33. Pius XII, Address, *Si la surcharge*, loc. cit., p. 701.

"In general-science courses we are enthusiastic, and justifiably so, in pointing out the extraordinary power of the scientific method for solving objective problems; equally important, it seems to me, is emphasis on the limitations of scientific procedures in areas that involve subjective judgments. Otherwise we lay ourselves open to the charge which would be leveled against anyone who tried to teach a general-education course in medicine, that we are giving future citizens a powerful tool without instructing them in its use or warning them of its dangers."

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The Journal of Higher Education

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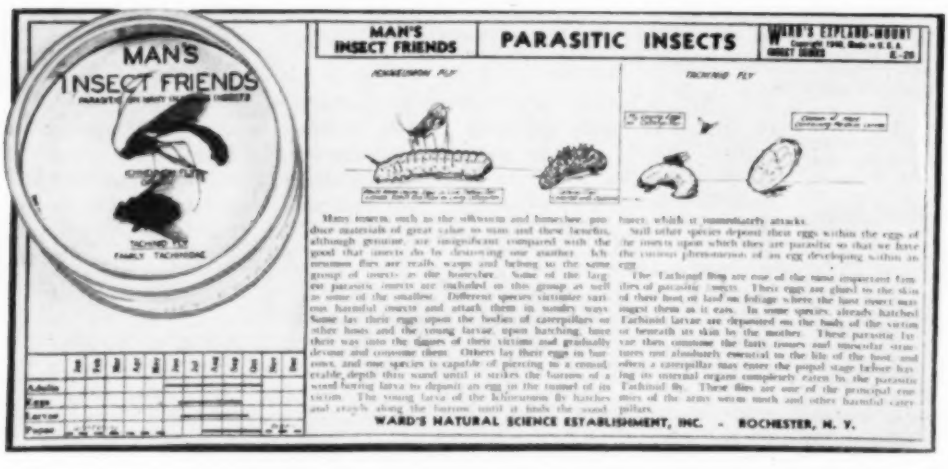

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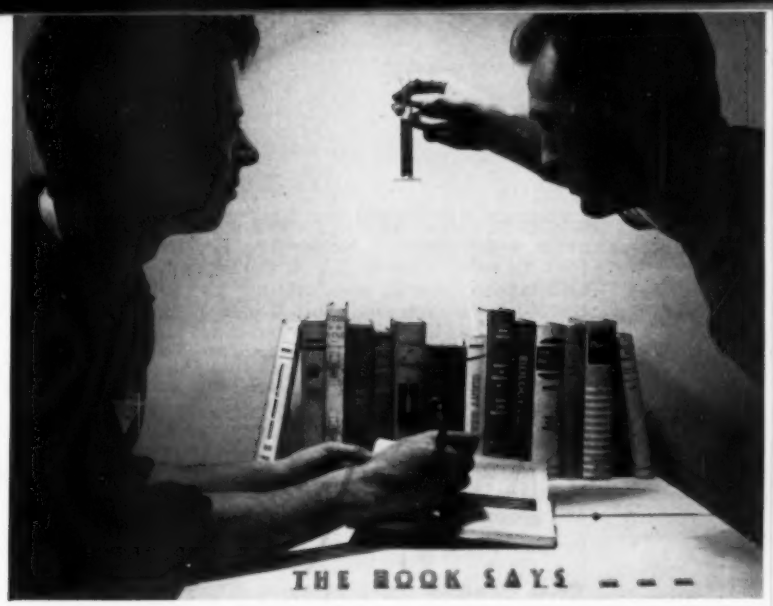

The Anatomy of Communism

• *By* ANDREW M. SCOTT. New York: Philosophical Library. 1951. Pp. XIII + 197. $3.00.

This work is an excellent analysis of certain aspects of Communist doctrine. Using the logical approach, the author dissects certain basic Communist concepts such as that of class, dictatorship of the proletariat, and democracy. He points out some of the glaring weaknesses of the system, such as its Utopianism and the need for force to convince its followers of its truth. One of the book's strongest points is the explanation of how Marx selected empirical facts to prove an *a priori* thesis. It is to be wished that the author had taken the time to give a philosophical proof of the falseness of the dialectic, since, as he himself states, the whole system collapses with the collapse of this one thesis. Numerous quotations from the writings of the Communist evangelists convince the reader that the author is presenting the Communist side of the question with great fairness, as, indeed, he does. A grasp of the contents of this book will certainly give the reader sufficient material to justify an anti-Communist position. The work is by no means exhaustive since it approaches the subject from neither the scientific nor the historical side, as the author himself points out. Neither does it try to present a positive case for the opposition. However, it gives a satisfactory and quite readable presentation of a very important part of the question. I recommend it highly to all who wish a clearer understanding of Communist logic and Communist doctrine.

Rev. J. R. Schlicht, C.S.Sp.
Department of History
Duquesne University

North of the Circle

• *By* FRANK ILLINGWORTH. New York: Philosophical Library. 1952. Pp. 254. $4.75.

It amazes one who has never visited the far North to learn that so many visitors succumb to its spell, either remaining there permanently or returning again and again. The journalist-author of this entertaining and informative narrative of life in the arctic capitulated at once, and his continued deep interest in the frozen world and its people is apparent throughout the book. Reading it is a pleasant experience for he writes spiritedly, enlivening his account with a wealth of anecdotes and stories of adventure. He makes plain that much we have thought to be fact is really fiction.

The author confines his story to the Norwegian, American, and Russian areas, although much concerning the latter region is necessarily speculation. There is an enlightening discussion of the problems involved in a polar war, as well as consideration of such lesser problems as the difficulties met in constructing and living in a snow igloo, the freezing of hot food before the meal is finished, and the plague of mosquitoes in summer. Much information is given concerning arctic and polar climate, travel and hunting and farming, the people of the far North both native and white, the position of women, the work of the doctor and the cleric, and many other topics. There are a number of halftone illustrations. *H. C. M.*

Chemistry in Action

• *By* GEORGE M. RAWLINS and ALDEN H. STRUBLE. Boston: D. C. Heath & Co. 1952. Pp. 575. $3.60.

A strongly made, carefully planned, and well written textbook for high schools, modern and attractive in content, arrangement, and design. Although it has 528 double column pages of study material, exclusive of the appendices, the book makes no pretense of being all-inclusive. There are more than 400 illustrations—line cuts and halftones—and careful summaries, groups of problems, and lists of reading topics and study projects at the end of each of its 46 "problems." The problems are grouped into nine teaching units. A teacher's handbook, laboratory manual, and tests and keys are available.

The authors appear to have succeeded rather well in attaining their two major objectives: (1) to help the pupil appreciate the role of chemistry in daily life, and (2) to help him learn to reason scientifically. No single textbook will, of course, fit the need of every school, but teachers considering a change of text will do well to give *Chemistry in Action* a careful examination. *H. C. M.*

The Magic Curtain

• *By* LAWRENCE LANGER. New York: E. P. Dutton & Co., Inc. 1951. Pp. x + 498. $6.60.

Although listed as the story of a life in two fields, theatre and invention, by far the greater portion of this autobiography is devoted to the stage. Consequently, the book would best be reviewed in a journal of the theatre or in a publication of general circulation rather than in one restricted to science. This volume will be a bit out of place in the science library. Mr. Langer does, however, have some knowledge of science gained through his work as an international patent

attorney, a field which brought him in contact with the early inventions of Kettering. But it is easy to see that his chief interest lies in the literary life, in authors and actors, and in the writing and staging of plays. In 1918, he founded the Theatre Guild which was eventually to become the resounding success it is today.

Mr. Langer has been responsible for producing many stage successes, plays written by the world's most famous playwrights and performed by the most famous actors of the period. His reminiscences of the theatre and theatre folk of the last thirty years will be of interest to anyone who follows the theatre, but his book contains little of direct concern to the scientist. There are about 100 excellent illustrations.

H. C. M.

The Molds and Man

• *By* CLYDE M. CHRISTENSEN. Minneapolis: University of Minnesota Press. 1951. Pp. VIII + 244. $4.00.

This is a timely, informative, and pleasantly nonpedantic book for laymen and for beginners in mycology. It is from the pen of a sound scientist who knows how to write. The reaction of one student who read it was, "Learning can be fun!" This book could well find a place in both school and public libraries.

In some 234 pages the author tells the story of the fungi, their function in nature, and how they live, grow, and multiply. Only in recent years has their significance in medicine, agriculture, and other fields been appreciated. Although they are not all harmful, some cause diseases in plants and animals, others attack stored grain, flour, dairy products, wood, fabrics, and protein goods. Fungi perform a useful function in the preparation of certain foods and such medicines as penicillin and streptomycin. Industrial mycology is now big business.

This book fills the gap between the brief accounts of the fungi ordinarily found in textbooks of botany, and advanced textbooks that are suitable for specialists in mycology. References for collateral reading are given at the end of each chapter. *H. C. M.*

The Nature of Things

• *By* DR. ROY K. MARSHALL. New York: Henry Holt & Co. 1951. Pp. X + 188. $2.95.

The author of this modest book is a highly trained scientist, a successful teacher, a consultant to the Atomic Energy Commission, a popular television showman and public lecturer, and "the best planetarium man in America." His book on the nature of things is based on the television programs he has presented weekly since 1948 over the National Broadcasting Company's network. We consider this book worth careful reading whether or not the reader has been trained in science.

Dr. Marshall's interest ranges from the very tiny to the very great, from the nucleus of the atom to the ends of the universe. He discusses atomic structure, x-rays, "discontented atoms," atom smashing and the atom bomb, light, stars, man-made rainbows, the expanding universe and other subjects. High school students will enjoy this book. So will laymen. In it the alert teacher will find valuable teaching ideas and apt illustrations that can be adapted to the school room with a view to making his science classes more lively and interesting. *H. C. M.*

(Continued on Page 36)

Industrial Alcohol

(Continued from Page 20)

absorption in 85 per cent sulfuric acid or in a hydrocarbon oil, to prevent polymerization.

The direct hydration of ethylene to ethyl alcohol is limited, thermodynamically, to low conversions, and the reaction is usually, therefore, carried out indirectly by first treating the ethylene with sulfuric acid. The ethyl sulfuric acid and ethyl sulfate formed are hydrolyzed to ethyl alcohol and sulfuric acid when treated with water.

For the future, natural gas can be expected to become increasingly important as a raw material. Variants of the Fischer-Tropsch process can be used. The first step is a partial combustion of the gas to a mixture consisting chiefly of carbon monoxide and hydrogen. The mixture is passed over a catalyst to produce mainly gasoline, together with a number of oxygenated organic compounds, of which alcohol is the most abundant. Known reserves of natural gas in the United States are enormous, and the manufacture of any appreciable fraction of our gasoline requirement from this material could produce, as a by-product, a very substantial part of our requirement of this important chemical commodity. •

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Use of Refrigeration

(Continued from Page 16)

30 per cent) occurs. Copper, aluminum and others remain ductile at the lowest temperatures.

Heat treatment of steels to secure special properties has been practiced for a long time. Very recently it has been discovered that cold treatment may greatly enhance the value of various substances including certain steels. The temperature range of such treatments is extending to lower and lower levels as information and facilities become available.

Resistance to flow of the electric current is observed to fall slowly as the temperature falls until a very low temperature is reached. With further lowering of the temperature the resistance may remain constant, rise sharply or, as in the case of several metals, it may fall abruptly to zero. These metals are then said to be superconductors. An electric current once started in a loop of a superconductor is expected to continue to flow without external aid as long as the specimen is kept cold. In an ordinary substance such a current would die instantly. The property of superconductivity has been utilized in a special radio detection device of high sensitivity.

Liquid helium itself has been found to be the strangest of all liquids. At ordinary pressures it will not freeze even at the lowest temperature thus far produced. Yet at very high pressures helium gas condenses to the solid state at temperatures much too high for the existence of the liquid state. For instance, if gaseous helium under a pressure of 5000 atmospheres is cooled it changes to solid helium at approximately 40°K; if the pressure is only 80 atmospheres it condenses at 5.2°K to a liquid which freezes on further cooling to 3°K; and if the pressure is 20 atmospheres or less liquid is formed at some temperature below 5.2°K, but no solid appears even at 0.01°K.

Liquid helium under saturation conditions undergoes a peculiar transition at 2.19°K. The new liquid is called Helium II. Helium II is by far the best thermal conductor known, having a conductivity at 1.8°K which is a few hundred times that of copper. It is able to wet all substances and tends to form a relatively thick film over all the surface available to it. One of the consequences of this particular property is that Helium II tends to establish a uniform level throughout a cold enclosure. It climbs the wall of the container, goes over the top and down the other side until either the container is drained or the level outside becomes the same as that inside. If the walls of the containing vessel are kept above 2.19°K the film evaporates and the vessel is soon emptied.

Helium II also tends to flow toward a source of heat. Its viscosity is negligibly small while that of ordinary liquid helium is very much larger. It is possible to produce an effect similar to osmosis by interposing a

porous wall between two bodies of Helium II one of which is kept a little warmer than the other. The liquid level on the warm side rises rapidly while that on the colder side falls.

An interesting theory has been proposed to account for the unusual behavior of Helium II. It is assumed that the liquid contains two species of molecules, one being ordinary liquid helium, the other being a super fluid whose viscosity is zero. Above 2.19° the percentage of normal liquid is 100. Below 2.19°K the percentage of superfluid varies from 0 at 2.19° to 100 at 0°K. In other words the colder the mixture the greater the concentration of superfluid. In the porous wall experiment superfluid passes through the wall easily from the region of high concentration to the region of lower concentration. The normal fluid, because of its relatively high viscosity can not compensate. Therefore the level rises on the warmer side.

As the temperature of a body approaches the absolute zero molecular activity becomes more and more sluggish. It is expected that advantage can be taken of this fact to secure more information about the nuclei of atoms. Perhaps nuclei whose magnetic moments are almost vanishingly small can eventually be aligned in a strong magnetic field and be explored zone by zone.

A great variety of the physical properties of solids, electric, magnetic, optic, thermodynamic, etc. are being studied at helium temperatures with the expectation of increasing our imperfect understanding of the solid state of matter. ●

★ ★ ★ ★ ★

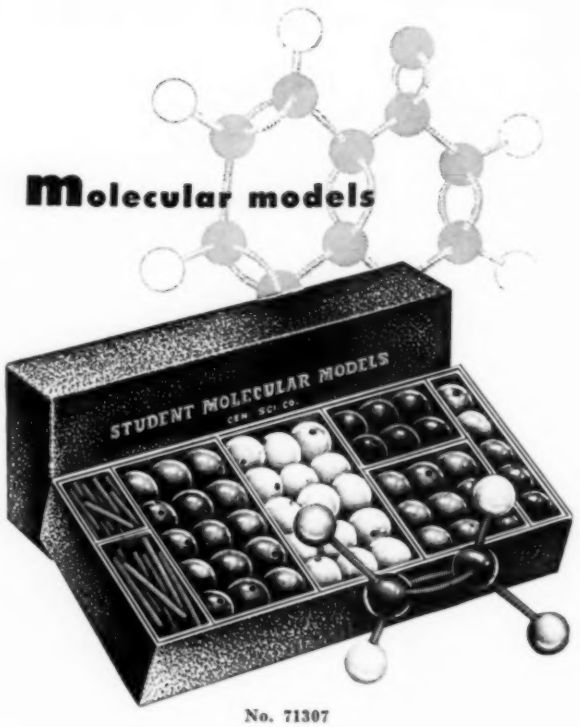
Oysters in the Shell

(Continued from Page 14)

under a microscope the sex of the oyster will become apparent, with the eggs resembling grains of corn in shape and with the much smaller and typical sperm cells in active movement.

Fertilization and development of oyster eggs can be observed easily. After a ripe female has been identified, a drop of milt containing eggs should be placed in a finger bowl or watch glass of sea water. A smaller drop containing sperms from a ripe male is then added. A drop of the mixture can be transferred to a microscope slide from time to time and the crowding of sperms around the eggs observed. After about two hours most of the eggs will have become fertilized, are spherical in shape, and beginning to show cell divisions. Interesting slides of eggs in various stages of division can be obtained and the actual process of division watched. In four to six hours ciliated embryos will be found swimming about and congregating near the surface. By siphoning these off into fresh sea water many of them will develop into independent oyster larvae in about 24 to 36 hours after fertilization at ordinary room temperature. Such observations largely are limited to those who can obtain fresh sea water, and are seasonal in nature. At a laboratory in Connecticut, however, it has been found possible to develop ripe gonads at any season by holding the oysters for a few weeks in

Molecular models



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The study of the structures of organic compounds has always been difficult to present to the student without the use of expensive models. The latest development for student study is a low-cost, compact set of models with which three-dimensional representations of molecules can be easily produced.

The set was developed according to the suggestions of Professor George F. Wright and other members of the department of chemistry of the University of Toronto. Colored wood balls represent atoms; ⅛" diameter coil springs represent multiple and cyclic valence bonds. Four holes, drilled at angles of 119° 28' in the black carbon balls, allow formation of the tetrahedron postulated by van't Hoff and LeBel; this arrangement permits showing diastereoisomerism and enantiomerism of substances such as lactic and tartaric acid.

Three lengths of springs include: 35 C-aliphatic bonds, 1½"; 35 C-hydrogen bonds, 1" (both aliphatic and hydrogen bonds correspond to bond radii of C-C and C-H as outlined by Pauling in *Nature of the Chemical Bond*), and 15 C-aromatic bonds, 1⅛" (for the formation of symmetrical benzenoid forms).

The colored balls, ¾" in diameter, include: 30 Carbon (black); 30 Hydrogen (white); 12 Oxygen (red); 18 Halogens (green); 5 Nitrogen (orange); 5 Sulfur (yellow). The diameter of the holes permits use of cut household matches for rigid bonds in permanent models.

No. 71307 Molecular Model set is sold complete with instructions for $5.00.

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salt water aquariums at a temperature between 20° and 30° Centigrade. Along the South Atlantic and Gulf Coasts some oysters with ripe gonads may be found at almost any time of year.

Oysters consume little oxygen, but when kept in an aquarium an air pump should be used to keep the water in good condition. A few of them may be placed in a balanced or semi-balanced marine aquarium with the other animals and plants present. Their ability to clear the water of fine silt or an over abundance of planktonic organisms is quite marked. Since they are plankton feeders no special additions of food are needed. A small cluster of oysters brought back from the shore in fresh sea water with all of the attached or associated animals alive makes an interesting illustration of a small marine bottom community. Some of the plants, such as *Ulva* or other green algae, and a few small fish such as the cling fish, gobies and sticklebacks which find refuge among the oysters, should be included.

All in all the oyster is a readily handled and interesting marine animal when used alive in the laboratory. It not only provides the student with a type form of mollusk demonstrating typical structures and special adaptations to its environment, but introduces to him an example of a renewable natural resource in need of better management and capable of providing richly one of the most needed foods, proteins, for human use. ●

★ ★ ★ ★ ★

An Island in the Tropics

(Continued from Page 22)

lined with fine rootlets and palm fibers, was located near the ground among the leaves of a low growing succulent plant. There were only two eggs, a number common to birds in that part of the world, instead of the four or five commonly laid by birds in the temperate zone where only one or two broods are reared during the course of the restricted nesting season. During the day the two eggs were often left uncovered, or the female, if present, sat on the edge of the nest because the heat of the humid atmosphere was sufficient to promote incubation. But as the temperature dropped at sunset she would settle down on the eggs for the duration of the night. On one occasion, in order to examine the contents of the nest, the bird was flushed. She ran along the ground actively fluttering her wings, feigning a wounded creature, but not uttering a sound. The bird was followed to encourage this behavior and to determine what she would finally do. After leading her intruder away for a distance of about twenty yards she flew to a low branch of a tree and at once began uttering a loud piercing trill. No sooner had this call echoed through the woods than it was answered by her mate in the distance. He immediately appeared on the scene and the two birds created such a commotion that it seemed to excite all of the other birds of the neighborhood. They added their voices of protest and a troop of monkeys started to howl. A kind of chain reaction was begun among the inhabitants which resulted in a pandemonium in that bit of jungle, all initiated by one little antbird.

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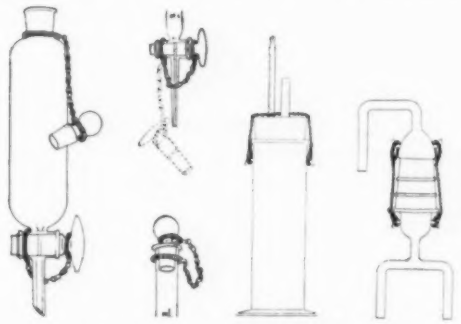

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Synthetic Detergents

(Continued from Page 18)

Space for this discussion is limited and many things must be left unsaid. However, it should be borne in mind that the products mentioned are the basic active ingredients only. It is easily seen how these may be built with such active salts as the tripolyphosphates, into detergents of wide use, just as soap is built with similar materials into such well known soap products as Rinso, Oxydol and Super Suds. The synthetics, because of their great activity, generally require more builders than the soaps. Industrial products are generally sold in highly concentrated form since the user has greater control of his processes than the housewife and therefore can build his product to the exact specification desired for his particular use.

A few industrial applications have been mentioned. Others include washing streets, cleaning metal surfaces for processing, cleaning felts on paper machines, cleaning dairy equipment, etc. In this last application nonionics are of special merit as they are compatible with the cationic germicides so frequently used.

We have mentioned only the sodium salts of the syndets. Many others can and will be used. The triethanolamine salt of the alcohol sulfate has long been used as a shampoo. The potassium and ammonium salts also are available. In one case, a detergent is marketed as the magnesium salt. Bar soaps of pure synthetic material have appeared and bars containing combinations of soap and synthetics were widely employed by the armed forces for use in sea water. Just how far the industry will continue to advance is highly speculative, but it should prove a field most challenging to the young chemists of the present day. ●

★ ★ ★ ★ ★

New Books

(Continued from Page 32)

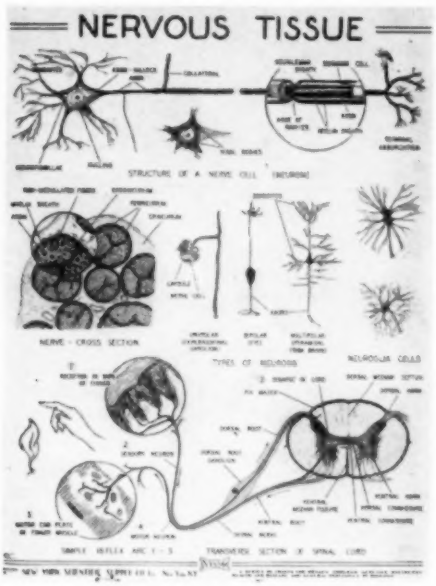
British Scientists

• *By* E. J. HOLMYARD. New York: Philosophical Library. 1951. Pp. VIII + 88. $2.75.

This little book is designed to direct increased and well deserved attention to the scientific achievements of British scientists from the time of Roger Bacon to the present day. Brief mention is given to some of the more noted British scientific societies and institutions that have played a major role in the development of scientific knowledge.

The distinguished author is a chemist and historian of note. He feels that the non-British world does not appreciate to the full the importance in the development of fundamental principles of the scientific work and thinking of such great scientists as Bacon, Gilbert, Harvey, Boyle, Newton, Dalton, Davy, Herschel, Faraday, Darwin, Kelvin, Lister, Crookes, Perkin, Ramsay, and others. Although only a small space is devoted to the individual scientists, the major contributions of each are clearly stated. There are a number of portrait illustrations. *H. C. M.*

NYSSCO HISTOLOGY CHARTS



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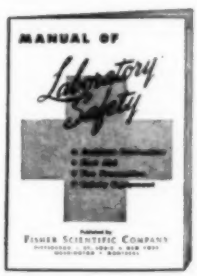

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- **"Safety Equipment Available for Use in Laboratories"**

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